

# RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

Vol. 63

DECEMBER, 1954

No. 6

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# RADIOLOGY

A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

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## Blood Radiation Dose During Radioiodine Therapy of Metastatic Thyroid Carcinoma<sup>1</sup>

S. M. SEIDLIN, M.D., A. AARON YALOW, Ph.D., and EDWARD SIEGEL, B.S.

AT MONTEFIORE Hospital, in the course of the last ten years, we have had an opportunity to study the effects of administration of large quantities of radioiodine to a considerable number of patients with metastatic thyroid carcinoma. Relatively early in our experience it became evident that radioiodine dosage is limited primarily by the effects of radiation delivered to the hematopoietic system by the circulating isotope.

Assuming that the radiation dose to the blood-forming organs is correlated with the radiation dose to the circulating blood, studies of blood radiation dosage during radioiodine therapy, together with the resulting effect on the hematologic picture, may establish the degree of radioisotope toxicity.

Marinelli and Hill (1) studied the blood radioiodine concentration in a number of patients, including 7 of the Montefiore Hospital series, and have calculated the resulting radiation received by the blood. Rawson, Rall, and Peacock (2) have discussed the effects of irradiation on some of the blood components due to the circulating  $I^{131}$  and have proposed limitations on radioiodine dosage. Stanbury *et al.* (3)

have reported blood and "plasma radiation" doses and their effects on the blood counts following the administration of large therapeutic amounts of  $I^{131}$ . On the basis of the tissue concentration of  $I^{131}$  determined at necropsy, several investigators (4-6) have reported the number of equivalent roentgens delivered to various organs.

The present study, a preliminary report of which has been published (7), is concerned with the radiation dose delivered to the blood during the various stages of  $I^{131}$  therapy for metastatic thyroid carcinoma, and with concomitant injury to the hematopoietic system. We have studied the influence of benign and malignant functioning thyroid tissue on the blood radiation dose, which has been calculated from the blood  $I^{131}$  concentration and the disintegration scheme of the isotope. Approximate values for the generalized total-body radiation have been estimated from the isotope concentration in blood, a readily available and measurable tissue whose radioactivity contributes a major portion to the generalized radiation. We have not considered radiation damage to specific organs due to their proximity to

<sup>1</sup> From the Medical Physics Laboratory, Medical Division, Montefiore Hospital, New York, N. Y. Accepted for publication in October 1953.

This investigation was supported in part by a research grant from the National Cancer Institute of the Institutes of Health, U. S. Public Health Service.

The  $I^{131}$  used in the investigation since 1947 was supplied on allocation from the Isotopes Division, Atomic Energy Commission, Oak Ridge, Tenn.

depots of radioiodine, such as the thyroid gland and urinary bladder.

In order to clarify further the effect of thyroid function on blood radioiodine levels, several hyperthyroid patients were similarly studied during radioiodine therapy.

#### PROCEDURES AND CALCULATIONS

Patients in this study received oral doses of  $I^{131}$ , most of which were assayed in "New York millicuries" (8). This unit, employed since 1947, is within 10 per cent of the current Bureau of Standards and Oak Ridge millicuries.

Determinations were made of the blood  $I^{131}$  concentration following 69 therapeutic doses to 26 patients with metastatic thyroid carcinoma. These studies were conducted for variable intervals of time, from one to thirty-five days after ingestion of the isotope. Blood samples were taken at frequent intervals during the first twenty-four hours following  $I^{131}$  administration and less frequently thereafter.

The radioiodine concentration of weighed samples of blood, designated as  $C_b$  [ $\mu\text{c/gm.}$ ], was determined by gamma-ray counting, using a Geiger counter tube and scaling circuit.<sup>2</sup>

Most of the determinations were made with a tetramethyl lead-filled Geiger tube (Technical Associates, Type TA-B1), counting liquid samples in a Marinelli beaker. The sensitivity was 450 counts/minute/ $\mu\text{c } I^{131}$ . Since 1951, bismuth cathode Geiger tubes with a sensitivity of 4,000–5,000 counts/minute/ $\mu\text{c } I^{131}$  for a similar geometry have been used.

The specific radioiodine concentration in blood, *i.e.*, the concentration of  $I^{131}$  per 100 mc administered, was plotted as a function of time. The following considerations will show how the radiation delivered to the blood by the beta and gamma radiation from  $I^{131}$  during any desired time interval was determined from a

measurement of the area under this curve for the given interval.

The rate at which radiation is delivered to any tissue by the beta rays emitted from a radioisotope, distributed uniformly within a tissue whose dimensions are large compared to the range of the beta rays, will be proportional to the isotope concentration [ $\mu\text{c/gm.}$ ] and to the average beta ray energy emitted per disintegration.

The mode of disintegration of  $I^{131}$  has been extensively studied during the past few years. The results have been tabulated by Hollander, Perlman, and Seaborg (9). According to the disintegration scheme proposed by Metzger and Deutsch (10) and confirmed by recent investigations (9), the average beta ray energy per disintegration is 199 kev. This value, used in the present work, is in substantial agreement with direct experimental values and the new British standard value of 197 kev (11).

From the relationships derived by Marinelli and his co-workers (12), it can be shown that the beta rays from a uniform concentration of 1  $\mu\text{c } I^{131}$  per gram will dissipate energy at a rate of 42.0 ergs/gm./hr. Using 93 ergs/gm. as equal to 1 roentgen equivalent physical (rep), the beta ray dosage rate to blood resulting from a blood  $I^{131}$  concentration of  $C_b$  [ $\mu\text{c/gm.}$ ] will be  $0.452 C_b$  [rep/hr.]. If the  $I^{131}$ , whose half-life we take to be 8.00 days, were in a biologically steady state, *i.e.*, if changes in its concentration were due only to physical decay, the total radiation delivered during the time that the  $I^{131}$  was present would equal 0.452 times the average physical life of the isotope, *i.e.*,  $(0.452)(8.00)(24)/0.693$  rep, which equals 125.1 rep.

Calculation of the radiation dose delivered to the blood by the gamma rays from  $I^{131}$  is a more difficult problem. Because of the long range of the gamma radiation, the dose rate at any location will depend on the concentration of the isotope at all other points in the body. As a result of the variation in geometry, this rate is not uniform over the body; at

<sup>2</sup> Throughout this paper, the units in which all factors are measured are indicated by the italicized expression in brackets.

any point, it is the sum of contributions from radiation sources differing in both distance and activity.

Bush (13) has calculated the approximate integral dose rate delivered to patients of various heights and weights when the entire body contains a uniform concentration of an isotope emitting gamma rays. By applying the methods of Marinelli, Quimby, and Hine (12) to the Metzger-Deutsch (10) disintegration scheme, it can be shown that the gamma rays from a point source of  $I^{131}$  deliver 2.41 r/mc/hr. at 1 cm. When the above value is applied to Bush's calculations for a patient 170 cm. long and weighing 70 kg., within whom there is a uniform concentration of  $1 \mu\text{C } I^{131}/\text{gm.}$  of tissue, the average radiation rate to the body will be 0.294 r/hr. With an average  $I^{131}$  concentration of  $C_t [\mu\text{C/gm.}]$  in the body tissues, the average gamma ray dose rate to tissue and to blood is therefore  $0.294 C_t [\text{r/hr.}]$ . If the isotope were in a biologically steady state, a total dose of  $81.5 C_t$  roentgens due to gamma radiation would be delivered during the entire time  $I^{131}$  was present.

The total dose rate due to both beta and to gamma radiation equals  $(0.452 C_b + 0.294 C_t) [\text{rep/hr.}]$ , where  $C_b$  and  $C_t$  are the average  $I^{131}$  concentrations in whole blood and tissue, respectively, measured in  $\mu\text{C/gm.}$   $C_t$  cannot be directly measured. Since  $C_b$  is directly determined, it is desirable to obtain, if possible, the ratio between  $C_t$  and  $C_b$ . Actually, this ratio between the concentration of the isotope in tissue and in blood will vary with the hematocrit and is a complex function of time, depending on the magnitude of the fraction of the circulating  $I^{131}$  which is organically bound.

It is possible, however, to make a rough estimate of the tissue/blood ratio,  $C_t/C_b$ , for the period shortly after ingestion, when only radioiodide is present. The duration of this phase varies from hours to days, depending on the functional state of the thyroid tissue. The estimation of the ratio is accomplished indirectly by consideration of the experimental data which

are available on (a) the ratio of the radioiodide concentration in whole blood to its concentration in plasma and (b) the ratio of the average  $I^{131}$  concentration in extrathyroidal tissue to that in plasma. Scott *et al.* (14) and Owen and Power (15) found that during the above mentioned iodide phase the  $I^{131}$  concentration in erythrocytes is approximately half that in plasma. For a patient with a hematocrit of 50 per cent this value would give a blood concentration of about  $(0.5) (1) + (0.5) (1/2) = 3/4$  of the plasma concentration. If the hematocrit is lower than 50 per cent, it follows that the ratio of blood concentration to plasma concentration will become higher. Rall *et al.* (16) and Myant *et al.* (17) obtained an erythrocyte/plasma radioiodide concentration ratio of about  $2/3$ , which for a 50 per cent hematocrit would result in a blood concentration of about  $(0.5) (1) + (0.5) (2/3) = 5/6$  of the plasma concentration.

Myant *et al.* (17) and Berson *et al.* (18) have shown that iodide space in equilibrium with blood plasma after administration of  $I^{131}$  is about one-third of the body mass, *i.e.*, that the average tissue concentration of extrathyroidal radioiodide is about one-third of the plasma concentration. From these considerations, it follows that the tissue concentration may be about one-half to one-third of the blood concentration during the iodide phase when the  $I^{131}$  is in the ionic state.

In the course of time, as the radioiodide is progressively synthesized into protein-bound  $I^{131}$  by functioning thyroid tissue and released into the blood, one may expect that the radioiodine concentration in tissue will become even lower relative to whole blood. This follows from the findings of Myant and Pochin (19) that the space of distribution of thyroxine is smaller than that of  $I^-$ .

To facilitate calculation, it will be assumed in this study that the ratio of the average  $I^{131}$  concentration in body tissues to that in the blood has a constant value. It will be further assumed, on the basis of the preceding considerations, that this

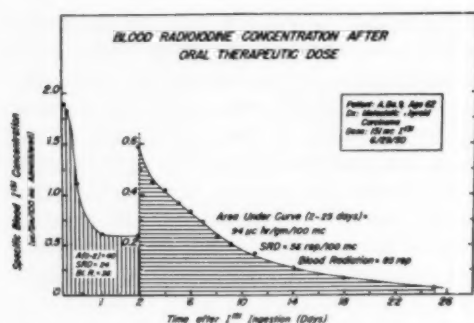


Fig. 1. Plot of the specific blood radioiodine concentration as a function of time following therapeutic dose to a patient. The radiation delivered to the blood is proportional to the area under the curve. As examples of the determination of the radiation delivered, two areas are indicated: 0-2 days and 2-25 days following ingestion of radioiodine. From these areas, the corresponding specific radiation doses [(rep/100 mc)] and blood radiation (rep) are calculated.

ratio is  $1/2$ , i.e.,  $C_t = C_b/2$ . Such an assumption should result in a reasonable upper limit to the radiation dose delivered. The reasonableness of this approximation is further supported by the several determinations of  $I^{131}$  concentrations in tissues obtained during post-mortem studies (4, 5, 6, 20).

Using the above assumptions, one obtains the following relationship:

$$\begin{aligned} \text{Dose rate to} \\ \text{blood [rep/hr.]} &= \text{beta ray contribution} + \\ &\quad \text{gamma ray contribu-} \\ &\quad \text{tion} \\ &= 0.452 C_b + 0.294 C_t \\ &= 0.452 C_b + 0.294 (C_b/2) \\ &= 0.599 C_b \end{aligned}$$

The specific radiation dose (srd) is defined (1) as the radiation delivered per 100 mc of the radioisotope administered. Since the blood radioiodine concentration varies with time due to biological processes and to physical decay of the isotope, the srd delivered to the blood is calculated from a graph of the specific blood  $I^{131}$  concentration [ $\mu\text{c/gm.}/100 \text{ mc administered}$ ] as a function of time. A typical curve is shown in Figure 1. The srd for any desired time interval is obtained by a planimetric determination of the area under the curve for the interval and substitution into the following expression:

$$\begin{aligned} \text{Specific radiation} \\ \text{dose to blood} &= \text{radiation delivered}/100 \\ &\quad \text{mc } I^{131} \text{ administered} \\ &= 0.599 \times \text{area under} \\ &\quad \text{specific blood } I^{131} \text{ con-} \\ &\quad \text{centration curve } [\mu\text{c} \\ &\quad \text{hr./gm.}/100 \text{ mc}] \end{aligned}$$

The radiation delivered during the period subsequent to withdrawal of the last blood sample is calculated on the assumption that the isotope within the blood is in a biologically steady state. While usually not valid, this convenient assumption will generally result in only a small error in the total srd. The error is particularly small when the  $I^{131}$  concentration in the terminal sample is relatively low.

Under these conditions, according to the calculations previously shown for the beta and the gamma radiation, the srd delivered to the blood for the interval from the last sample to the time when the blood no longer contains  $I^{131}$ , will equal  $125.1 S_t + 1/2 (81.5) S_t = 166 S_t$ , where  $S_t$  is the observed specific  $I^{131}$  concentration of the final blood sample drawn.

The total radiation delivered following administration of a particular dose of  $I^{131}$  is the product of the srd [rep/100 mc] and the number of 100 mc  $I^{131}$  administered. Figure 1 illustrates a representative calculation of srd and radiation delivered to the blood following a dose to a patient. Complete calculations for the srd and blood radiation are presented, based on the areas under the specific blood radioiodine concentration curve for two intervals, 0-2 days and 2-25 days after ingestion of the radioiodine.

The calculated radiation dose to body tissue will depend to a marked degree on the value of  $C_t/C_b$  used. If the average tissue concentration of radioiodine were exactly half that in blood, the beta ray dose to tissue would be half that to blood and it can easily be shown that the calculated combined beta and gamma radiation dose to tissue would be 0.62 that to blood. However, because of the uncertainty in  $C_t/C_b$ , which is probably somewhat less than  $1/2$ , we have assumed that the generalized body radiation is half of



the calculated dose to the blood. An identical ratio will, of course, be found for the specific radiation dose to the body.

The radiation delivered by the gamma rays from the  $I^{131}$  which may be concentrated in the thyroid gland has not been included in the above calculations. From values given by Bush (21), this source will deliver radiation to the body at an average rate of about 4 mr/mc hr. For a euthyroid patient, the thyroidal radioiodine may contribute a maximum of roughly 3 r/100 mc, much less than the radiation received from radioiodine in the blood and non-thyroidal tissue.

Following Bush (21), one can show that the generalized whole-body radiation rate from  $I^{131}$  in the bladder is approximately 6 mr/mc hr. The maximum generalized body srd delivered by this source is about 7 r/100 mc, which is small relative to the srd received from  $I^{131}$  in the blood and in other tissues. The gamma radiation to organs close to the bladder will be very much higher than this average value.

Marinelli and Hill (1) have used an approximation (12) to calculate the radiation dose at the center of a model human trunk, which they have assumed to be a cylinder 60 cm. high and with a radius of 20 cm. The total gamma and beta ray radiation reported by them is 1.63 times as large as the combined radiation which would be obtained by use of the method adopted in the present study.

This difference in the calculated radiation dose is due to (a) our use of the Metzger-Deutsch decay scheme for  $I^{131}$  instead of the earlier one of Downing, Deutsch and Roberts (22), (b) use of the average gamma ray dose over the entire body instead of the maximum value of the gamma dose found at the center of a rather large model patient, and (c) the assumption that the average tissue concentration of  $I^{131}$  is half that in whole blood instead of being equal to the blood concentration.

Included in our series are data for four doses of radioiodine which consisted of a mixture of  $I^{131}$  and  $I^{130}$  (12.4 hour half-life).

In Tables II and IV, the  $I^{130}$  doses are italicized. Since the tissues are unable to differentiate among the various iodine isotopes, the fraction of the administered iodine, stable or radioactive, present in a gram of tissue is independent of the isotope used. However, the radiation delivered by the short-lived isotope, or a mixture of the two isotopes, will be less than for a similar concentration of  $I^{131}$  alone. In order to compare biological effects of these four doses with the effects of the 65  $I^{131}$  doses administered, the radiation to the blood in all cases has been calculated by use of the physical factors for  $I^{131}$ . Consequently, the actual radiation from the doses of mixed isotopes is less than that herein reported.

#### ERROR ESTIMATIONS

The following are the principal sources of error in determination of the radiation delivered to the blood: (a) weighing and preparation of sample; (b) determination of the relative counting rate of the blood sample and the administered dose; (c) drawing of the most representative curve of specific  $I^{131}$  concentration *vs.* time on the basis of the observed points; (d) planimetric determination of the area under this curve; (e) determination of the biological and physical factors relating radiation dose to the area under the curve.

We have measured the  $I^{131}$  concentration in two closely spaced blood samples taken after the blood concentration has become relatively constant. From the results, we estimate the uncertainty in procedures (a) and (b) to be approximately 3 per cent. Duplicate independent plotting and determination of areas have shown the average uncertainty in procedures (c) and (d) to be approximately 10 per cent.

The following components contribute to the uncertainty in procedure (e).

In order to compare the amount of radiation received from radioiodine doses given to different patients, the same factor has been used throughout to convert the area under the curve to specific radiation received. Using Bush's data (13), it



TABLE I: CRITERIA FOR GROUPING OF PATIENTS ACCORDING TO  $I^{131}$  UPTAKE IN THYROID GLAND AND IN METASTASES FROM THYROID CARCINOMA<sup>1</sup>

Group	Status	$I^{131}$ Uptake in Thyroid Gland
I	<i>All or Most of Thyroid Gland Present</i>	
II	Without uptake in metastases	$>10\%$
IIIa	With uptake in metastases	$>10\%$
IIIb	<i>All or Most of Thyroid Gland Absent</i>	
IV	Partial ablation; without uptake in metastases	$3-10\%$ <sup>2</sup>
V	Total ablation; without uptake in metastases	$<3\%$ <sup>2</sup>
VI	Partial or total ablation; with uptake in metastases	$<10\%$
VII	Total ablation; cessation of uptake in metastases	$<3\%$
VIII	<i>Hyperthyroid Gland (Non-Neoplastic)</i>	
IX	Without metastases	$>45\%$ (24 hours)

<sup>1</sup> Uptake in the thyroid gland and in metastases is demonstrated and measured with a Geiger counter, usually two days after administration of a tracer dose of  $I^{131}$ .

<sup>2</sup> This criterion is based on our studies showing that patients having an uptake of less than  $3\%$  two days after the test dose, or less than  $1\%$  on the third day, probably have no significant amount of residual thyroid tissue.

can be shown that the maximum variation from the standard conversion factor between area and srd is only 8 per cent for patients varying from 40 to 100 kg. in weight and from 140 to 200 cm. in height.

The calculated gamma radiation dose delivered to the blood depends also on the value used for  $C_t/C_b$ . An extreme variation in this ratio, from 1.0 to 0.0, will produce a variation of only  $\pm 25$  per cent in the calculated value of total blood radiation. The calculated results for the generalized body radiation will, however, be approximately proportional to  $C_t/C_b$ . For example, a 50 per cent uncertainty in this ratio will produce an uncertainty of about 40 per cent in the calculated whole-body radiation.

In the preceding discussion, the assumption has been made that all beta radiation from the blood  $I^{131}$  is completely absorbed within the blood. If this assumption were grossly invalid, it would result in a decrease of the beta ray energy absorption in blood, and hence in the calculated radiation dose to blood. The accurate calculation of the magnitude of the resulting correction, which involves the variation

in beta ray dose, as well as in the relative blood content with blood vessel size, is quite difficult. However, Gregersen (23) has stated that only 10 to 15 per cent of the blood in the vascular bed is in capillaries and other small vessels. The correction for incomplete beta ray absorption within small vessels is further reduced by the following considerations: (a) the blood in the small vessels also absorbs beta rays from extravascular  $I^{131}$ , whose concentration has been shown to be about half that of vascular radioiodine; (b) part of the blood in small vessels is contained within organs, such as the liver, which are so vascular that the blood in each capillary is not only irradiated by the blood which it contains, but by beta rays from blood within the many capillaries surrounding it. For these reasons, the undetermined but probably small correction of the radiation dose, to account for incomplete beta ray absorption within the blood, has not been made.

Any uncertainty in basic physical quantities relating to the  $I^{131}$  decay, such as half-life and disintegration energy, will affect the uncertainty in calculations for all doses in the same manner. Use of the most recent values (9, 11) of the disintegration scheme of  $I^{131}$  would reduce the calculated radiation dose by 3 to 6 per cent.

From the above considerations, we estimate that the maximum uncertainty in the determination of the blood radiation dose may be about 50 per cent when the blood samples have been obtained for several days following ingestion of  $I^{131}$ . In most instances the uncertainty will be less.

#### BLOOD AND BODY RADIATION

In order to investigate the correlation between srd and thyroid status and uptake in metastases, we have grouped our patients according to the criteria given in Table I. The radiation delivered to the blood for all radioiodine doses studied is listed in Table II, together with the patient status.

TABLE II: RADIATION DELIVERED TO THE BLOOD DURING RADIOIODINE THERAPY

Patient, Sex, and Age <sup>1</sup>	I* Dose			Group <sup>1</sup>	Days Followed	Specific Radiation Dose (SRD) (rep/100 mc)					Total Radiation Delivered by I* Dose (rep)
	Date	Activity (mc <sup>2</sup> )	Cumulative Activity (mc <sup>2</sup> )			0-24 hr.	24-48 hr.	2 Days to Last Point	Last Point to Infinity	Total <sup>1</sup>	
R. A., F, 30	4/10/47	103	105	I	21	14.6	2.0	11.6	0.6	29	30
B. A., F, 21	9/3/48	57	60	I	4	25.2	4.8	1.4	5.8	37	21
	4/17/50	76	138	IIIb	5	18.7	2.8	0.6	0.3	22	17
A. Be., F, 59	1/13/47	70	75	IV	18	22.1	6.0	7.3	1.5	37	26
	2/19/48	99	243	IV	35	15.9	8.2	56.1	1.2	75	74
	4/14/48	81	326	IV	3	25.6	10.2	5.0	42.8	83	67
	5/19/48	131	457	IV	23	28.0	11.8	35.8	3.4	78	106
	6/29/50	151	2,060	IV	25	15.3	8.7	56.4	4.9	85	129
A. Bl., F, 55	8/6/52	69	73	II	23	30.7	9.0	68.6	5.8	114	79
	8/28/52	62	135	IV	13	49.1	19.0	34.8	15.6	118	74
J. B., M, 48	11/2/50	90	92	I	20	8.2	1.7	15.3	2.3	27	25
R. B., F, 28	11/17/52	4	4	VI	7	4.2	8.7	58.5	106.2	177	7
B. Bo., F, 55	2/11/48	94	96	IIIa	10	15.4	1.8	2.2	2.1	22	20
B. Br., M, 50	4/28/44	55	83	IV	1	14.5					
		3	105								
	1/6/47	49	214	IV	12	25.6	5.6	2.1	9.8	43	21
			111								
	11/11/48	95	423	V	2	27.8	7.0				
			111								
	4/27/50	178	632	V	19	26.3	5.9	11.3	1.4	45	80
			111								
	4/5/51	164	822	V	13	26.3	8.0	20.2	8.4	63	103
			111								
A. C., M, 60	2/2/50	127	139	IV	8	22.0	8.1	3.4	0.4	34	42
S. C., F, 56	4/14/50	108	229	IIIb	7	26.1	9.4	3.6	0.5	40	42
S. D., F, 73	4/16/48	16	23	VI	7	11.3	7.4	32.4	40.3	92	14
M. E., F, 34	10/9/50	8	8	VI	22	15.0	22.1	88.1	19.9	145	11
	1/25/51	10	18	VI	11	14.9	19.5	121.2	66.4	222	21
J. F., M, 58	3/13/47	100	110	I	21	17.0	2.6	8.7	1.6	30	30
	7/11/47	97	302	IV	17	17.8	5.9	31.1	6.6	61	59
	11/20/47	96	499	IV	21	19.8	3.3	10.8	1.4	36	34
	4/7/48	89	590	IV	22	21.7	3.8	15.0	0.7	41	37
A. F., F, 66	4/27/51	153	196	IV	14	28.1	8.4	11.6	3.7	52	79
	6/8/51	122	323	IV	13	20.9	7.0	7.2	0.8	36	44
D. G., F, 50	6/11/48	12	14	I	3	14.1	2.0	0.6	3.3	20	2
L. G., M, 56	12/18/47	97	98	I	6	23.0	8.6	3.4	2.7	38	37
A. K., F, 65	6/20/46	7	7	VI	2	15.8	1.2				
		15	15								
	8/31/46	28	35	VI	10	15.8	1.8	4.2	5.8	27	7
			15								
F. L., F, 49	12/20/49	43	743	IV	8	28.6	8.1	5.9	1.6	44	18
L. L., F, 53	1/19/47	10	12	I	4	26.3	5.8	3.8	5.8	42	4
	10/29/47	99	380	IV	6	11.5	8.1	16.8	29.0	66	65
	12/18/47	50	431	IV	5	29.6	5.0	9.8	21.8	66	33
	6/17/48	20	459	IV	1	26.0					
B. L., F, 61	3/17/49	95	156	IV	6	16.4	5.4	5.8	11.5	39	37
E. M., F, 39	3/16/51	8	8	VI	13	11.0	7.7	50.3	31.4	100	8
S. M., M, 47	6/1/50	10	10	VI	21	6.3	8.8	86.5	10.1	112	11
	9/6/50	9	19	VI	18	10.6	10.6	95.5	16.2	133	12
R. M., M, 38	9/22/49	68	70	I	23	12.7	2.1	19.5	1.4	36	25
	11/11/49	54	127	IIIa	8	12.9	10.7	6.8	3.0	39	18
B. N., F, 55	2/16/50	197	221	IV	30	18.9	7.6	50.3	1.8	79	156
	3/31/50	208	432	IV	11	20.1	7.8	73.4	51.1	152	316
	5/18/50	193	626	IV	22	22.2	11.7	86.6	8.7	129	249
	6/23/50	198	825	IV	22	22.1	10.2	57.2	5.9	95	188
	8/24/50	168	995	IV	29	20.2	20.3	137.0	4.8	182	306
	11/24/50	93	1,090	IV	21	17.0	7.3	51.2	6.1	82	77
	1/24/51	89	1,182	IV	31	24.0	10.1	92.4	0.2	127	113
A. Ols., F, 44	3/19/51	7	7	VI	13	14.9	1.2	8.2	5.4	30	2

Table continued on page 804.

TABLE II: RADIATION DELIVERED TO THE BLOOD DURING RADIOIODINE THERAPY (Continued)

Patient, Sex, and Age <sup>1</sup>	I* Dose			Group <sup>3</sup>	Days Followed	Specific Radiation Dose (SRD) (rep/100 mc)					Total Radiation Delivered by I* Dose (rep)
	Date	Activity (mc <sup>2</sup> )	Cumulative Activity (mc <sup>3</sup> )			0-24 hr.	24-48 hr.	2 Days to Last Point	Last Point to Infinity	Total <sup>4</sup>	
L. O., F, 41	11/20/46	108	110	II	15	13.9	2.1	13.7	3.5	33	36
	12/6/46	65	175	IV	13	25.8	6.5	4.8	0.6	37	25
A. Olz., M, 76	6/27/50	10	10	VI	13	11.1	2.5	26.1	17.1	57	6
T. P., F, 32	5/12/52	5	6	VI	22	6.8	2.7	96.0	6.5	110	6
S. S., F, 40	4/18/50	19	75	IV	7	18.0	2.8	4.2	7.4	33	6
	5/4/50	91	167	IV	12	16.5	3.4	9.5	5.4	35	32
	6/15/50	186	355	IV	20	20.1	4.0	6.2	1.0	31	58
M. S., F, 57	1/3/46	4	108	IV	4	30.9	7.7	4.5	10.2	54	2
			220								
	3/16/46	40	148	IV	2	26.3	6.2				
		48	268								
	8/31/46	57	225	IV	27	26.4	4.1	11.9	1.1	43	25
			268								
	9/28/46	63	288	IV	13	25.9	4.8	5.3	3.0	39	25
			268								
	10/11/46	94	382	IV	19	25.6	8.0	11.8	2.0	48	45
			268								
	12/26/46	65	447	IV	12	32.3	10.2	14.8	7.6	65	42
			268								
	1/7/47	51	498	IV	11	33.9	10.0	18.1	12.3	75	38
			268								
	6/26/47	96	598	IV	15	27.2	9.1	17.8	6.8	61	58
			268								
D. S., F, 19	12/29/47	85	86	II	18	13.8	2.6	16.1	2.3	35	30
W. S., M, 58	11/2/50	90	92	I	19	19.1	4.2	11.4	2.5	38	34
E. S., F, 36	6/19/50	8	8	VI	23	2.2	1.3	12.1	6.5	22	2
	8/28/50	8	15	VI	12	3.8	1.4	12.3	13.2	30	2
A. V., M, 46	7/10/47	48	51	I	12	10.6	2.6	10.7	10.1	34	16
S. W., F, 40	1/8/48	87	90	II	11	15.0	3.9	20.0	12.3	51	45
	1/22/48	94	184	IV	22	21.3	4.3	5.5	0.4	31	30
	3/3/48	128	314	IV	13	24.6	8.4	5.3	1.4	39	50
	4/28/48	89	405	IV	8	24.5	4.8	5.5	4.1	38	34
	2/10/49	83	715	IV	15	18.7	2.6	3.4	5.8	30	25
	5/25/50	196	1,023	V	13	25.6	4.0	2.2	0.5	32	64
	10/13/52	77	1,825	IV	17	19.9	4.2	1.4	0.1	26	20
	1/5/53	101	1,990	IV	8	18.5	2.8	0.7	0.3	22	22
D. Y., F, 68	7/15/46	29	30	IV	1	18.6					
		10	11								
	7/23/46	30	61	IV	1	23.7					
			11								
	12/11/46	120	198	IV	12	15.0	4.3	30.8	22.4	72	86
			11								

<sup>1</sup> At first dose.<sup>2</sup> Italicized values indicate I<sup>131</sup>.<sup>3</sup> See Table I for criteria used in grouping.<sup>4</sup> For blood concentration curves followed for less than 3 days after ingestion of I<sup>131</sup>, the total srd delivered has not been calculated in view of its large inherent uncertainty.

**Terminology of Table II:** Italicized values of I\* dosage in the columns labeled "Activity" and "Cumulative Activity" indicate I<sup>131</sup>. The column captioned "Cumulative Activity" lists the total administered activity up to and including the particular dose tabulated. It includes radioiodine doses following which blood studies were not conducted and hence will total more than the sum of the activities of the individual doses tabulated. The status of the patient is classified according to the scheme of Table I and is given in the column headed "Group." The specific radiation dose, defined as the number of rep delivered for each 100

mc I<sup>131</sup> administered, is given for the various time intervals indicated. The last column gives the total radiation delivered to the blood by the tabulated dose of radioiodine. It is the product of the total srd and the number of 100 mc obtained from the "Activity" column.

For patients with metastatic thyroid carcinoma whose blood radioiodine concentration was studied for at least four days following a therapeutic dose, the specific radiation dose to the blood, de-

livered during the period from ingestion of the isotope until its concentration in the blood is negligible, has varied from 20 to 182 rep per 100 mc administered. The average value was  $56 \pm 34^3$  rep/100 mc. Some hyperthyroid patients (Group VI) show higher values of srd. Marinelli and Hill (1) in their study of 32 doses administered to 20 patients with thyroid carcinoma report an average srd of 108 rep/100 mc. Their average srd, when modified to conform to the assumptions and factors used in the present study, equals 66 rep/100 mc.

The radiation following a single therapeutic dose has been calculated to be as high as 316 rep to the blood, and approximately half as high to the whole body, if one assumes that the blood  $I^{131}$  concentration is twice that in tissue. This radiation was delivered after administration of 208 mc of  $I^{131}$ , the largest single dose in our series (Patient B. N., 3/31/50), resulting in the second largest srd to blood (152 rep/100 mc) and a generalized body srd of *c.* 76 rep/100 mc.

A generally accepted value for the median lethal dose of external radiation to man is 400 r, when delivered within a very short time (24). Even for the above patient (B. N.), delivery of an equivalent amount of whole-body radiation would probably require over 500 mc of  $I^{131}$ , a quantity several times higher than our usual doses (100–120 mc). It is also probable that the LD 50 for radiation from  $I^{131}$  would be higher than 400 rep, since with this isotope the radiation is delivered over a period of approximately two weeks, with one-third to one-half being delivered in the first two days after administration. It would seem, however, that  $I^{131}$  doses exceeding 250 mc might deliver generalized body radiation close to 200 r (24), the 5 per cent lethal dose for short duration exposure, to patients having a high blood srd and a high ratio of tissue to blood radioiodine concentrations.

Rawson, Rall, and Peacock (2) have stated that in prescribing a therapeutic

dose of  $I^{131}$  they restrict the amount of radioactive iodine to a level which, on the basis of a tracer dose, they calculate to deliver less than 500 rep to the blood. This limitation is a desirable one. However, inasmuch as these investigators have used the factors and assumptions of Marinelli and Hill (1), which will give results for the blood srd 1.63 times as high as those of the present study, we believe that they have overestimated the calculated blood radiation dose delivered to their patients.<sup>4</sup>

In order to compare the generalized body radiation calculated from blood concentration curves with that determined from urinary excretion data, concurrent studies of the blood and urine were made following 7 post-thyroidectomy doses to 5 hospitalized patients with slightly functioning or non-functioning metastases. In our calculations the assumptions were made that all  $I^{131}$  not excreted in the urine was uniformly distributed in the body and that the body srd was one-half that calculated for the blood.

The body srd as calculated from the urinary excretion was 2 to 11 times higher than that calculated from the blood data. A part of this discrepancy might be due to concentration of the isotope in undetected metastases. We believe, however, that it is primarily attributable to the faulty assumption inherent in the calculations from urinary data, *i.e.*, that all  $I^{131}$  not found in the collected urine is uniformly distributed in the body. Furthermore, for thyroidectomized patients whose radioiodine retention is small, failure to collect all of the urine, though causing only a small per cent error in determination of the urinary excretion, can result in a large systematic per cent error in the calculated  $I^{131}$  retention, *e.g.*, a 5 per cent loss in collection, reducing the calculated excre-

<sup>4</sup> In publications which have appeared since preparation of this manuscript (Tr. Am. Goiter A., 1952, pp. 290–304; Am. J. Roentgenol. 70: 274–282, August 1953), these investigators have indicated that they now employ a different method for calculation of the blood radiation dose, giving somewhat reduced values for the calculated radiation.

<sup>3</sup> Standard deviation.

TABLE III: RELATION OF LEUKOPENIA TO BLOOD RADIATION IN 14 PATIENTS EXTENSIVELY TREATED WITH RADIOIODINE

Degree of Leukopenia	Number of Patients	Range of Blood Irradiation Prior to Onset of Leukopenia	
		Duration (months)	Total Dose (rep)
None (WBC >4,000)	6	3-66	60- 600
Mild (WBC: 3,000-4,000)			
Transient (duration <1 month)	3	1-16	50- 250
Persistent (duration >1 month)	6	3-21	90-1,250
Severe (WBC <3,000)			
Transient (duration <1 month)	7	3-23	70-1,250
Persistent (duration >1 month)	2	5-16	175-1,600

tion from 95 per cent to 90 per cent, will double the calculated retention of the  $I^{131}$ . We therefore believe that the body radiation calculated from blood concentration is more accurate than that calculated from urinary excretion.

#### HEMATOLOGIC EFFECTS OF BLOOD IRRADIATION

In this paper, the hematologic effects of radioiodine therapy in our series will be briefly presented. A more detailed publication on the subject is planned.

In order to correlate the observed hematologic effects with the radiation dose received by the blood, we have estimated the cumulative blood radiation preceding various dates during the course of  $I^{131}$  therapy. The total radiation is estimated by averaging the blood  $srd$ 's delivered prior to the time in question and multiplying by the cumulative activity administered.

It has been our practice to restrict the amount of  $I^{131}$  administered at one time to a patient to a maximum of about 200 mc. We have observed no untoward effects other than a temporary leukopenia following a single therapeutic dose, the largest one of which in our series was 208 mc administered to B. N. on 3/31/50.

The largest total amount of  $I^{131}$  received by one of our patients was 2,300 mc over a period of two and a half years (Patient A. Be.). Another (S. W.) has received 2,000 mc during the past five years. Although these two patients received an

estimated blood radiation dose of 1,600 rep and 650 rep, respectively, no lasting effects on the hematopoietic system were observed.

To patient B. N. we administered 5 doses totaling almost 1,000 mc over a six-month period (February 1950 to August 1950). We have reported (25) the striking regression of the disease, with subsequent onset (June 1951) of a severe persistent leukopenia after delivery of about 1,600 rep to the blood. The leukopenia persisted for almost two years (September 1950 to August 1952) in either a mild or a severe form. For this two-year period, the patient received radioiodine (300 mc) only during the first nine months. In April 1953, she showed marked anemia, which improved after several transfusions of whole blood.

In our series of 14 patients who were extensively treated with radioiodine, 6 showed no leukopenia ( $WBC < 4,000$ ) at any time during the course of therapy. In the others mild or severe leukopenia ( $WBC < 3,000$ ), transient or persistent (duration greater than one month), developed after amounts of blood radiation shown in Table III.

The wide range of radiation resulting in leukopenia is undoubtedly a reflection of the great variability in radiosensitivity of the hematopoietic systems of individual patients. Variations in the length of time required for delivery of the radiation, and the initial hematological status of the patients, are important contributing factors.

One patient (J. F.) received, over a four-year period, a blood radiation dose estimated roughly at 600 rep following a total of 1,450 mc  $I^{131}$ . Although never during the course of radioiodine therapy was there evidence of leukopenia, he died with terminal subacute myelogenous leukemia. Since this is the only case, to our knowledge, of leukemia in a total of several hundred recorded patients with carcinoma of the thyroid treated with radioiodine, one can at present make no statement regarding any possible correlation between radio-



TABLE IV: VARIATION OF SRD WITH FUNCTIONAL STATUS OF THYROID GLAND AND THYROID METASTASES

Patient	Date of Dose <sup>1</sup>	Group	srd			24-Hour Thyroid Uptake (%)
			0-2d	2d-Inf.	Total	
B. A.	<i>9/3/48</i>	I	1.00	1.00	1.00	13
	<i>4/17/50</i>	IIIb	0.72	0.11	0.60	2
A. Be.	<i>1/13/47</i>	IV	1.00	1.00	1.00	8
	<i>2/19/48</i>	IV	0.87	6.40	2.23	4
	<i>4/14/48</i>	IV	1.24	4.40		
	<i>5/19/48</i>	IV	1.42	4.40	2.10	3
	<i>6/29/50</i>	IV	0.82	6.70	2.25	
A. Bl.	<i>8/6/52</i>	II	1.00	1.00	1.00	33
	<i>8/28/52</i>	IV	1.72	0.68	1.04	10
B. Br.	<i>1/6/47</i>	IV	1.00	1.00	1.00	6
	<i>11/11/48</i>	V	1.09			3
	<i>4/27/50</i>	V	1.06	0.99	1.03	
	<i>4/5/51</i>	V	1.13	2.40	1.46	
M. E.	<i>10/9/50</i>	VI	1.00	1.00	1.00	55
	<i>1/25/51</i>	VI	0.93	1.70	1.53	64
J. F.	<i>3/13/47</i>	I	1.00	1.00	1.00	12
	<i>7/11/47</i>	IV	1.15	3.65	1.99	5
	<i>11/20/47</i>	IV	1.13	1.15	1.14	2
	<i>4/7/48</i>	IV	1.24	1.26	1.25	3
A. F.	<i>4/27/51</i>	IV	1.00	1.00	1.00	12 <sup>2</sup>
	<i>6/8/51</i>	IV	0.74	1.02	0.82	9 <sup>2</sup>
A. K.	<i>6/20/46</i>	VI	1.00			— <sup>2</sup>
	<i>8/31/46</i>	VI	1.05			— <sup>2</sup>
L. L.	<i>1/19/47</i>	I	1.00	1.00	1.00	16 <sup>2</sup>
	<i>10/29/47</i>	IV	0.61	4.80	1.60	13 <sup>2</sup>
	<i>12/18/47</i>	IV	1.08	3.30	1.60	19 <sup>2</sup>
S. M.	<i>6/1/50</i>	VI	1.00	1.00	1.00	88
	<i>9/6/50</i>	VI	1.40	1.15	1.19	72
R. M.	<i>9/22/49</i>	I	1.00	1.00	1.00	26
	<i>11/11/49</i>	IIIa	1.59	0.47	0.94	2 (3d)
B. N.	<i>2/16/50</i>	IV	1.00	1.00	1.00	
	<i>3/31/50</i>	IV	1.31	2.38	2.07	
	<i>5/18/50</i>	IV	1.59	1.83	1.76	
	<i>6/23/50</i>	IV	1.68	1.18	1.18	
	<i>8/24/50</i>	IV	2.10	2.73	2.30	
	<i>11/24/50</i>	IV	0.86	1.10	1.03	
	<i>1/24/51</i>	IV	1.29	1.78	1.60	
L. O.	<i>11/20/46</i>	II	1.00	1.00	1.00	15
	<i>12/6/46</i>	IV	2.02	0.37	1.11	— <sup>2</sup>
S. S.	<i>4/18/50</i>	IV	1.00	1.00	1.00	6 <sup>2</sup>
	<i>5/4/50</i>	IV	1.13	1.30	1.18	9 <sup>2</sup>
	<i>6/15/50</i>	IV	1.15	0.62	0.96	
M. S.	<i>1/3/46</i>	IV	1.00	1.00	1.00	
	<i>3/16/46</i>	IV	0.84			
	<i>8/31/46</i>	IV	0.75	0.90	0.80	
	<i>9/28/46</i>	IV	0.80	0.56	0.73	
	<i>10/11/46</i>	IV	0.87	0.94	0.89	
	<i>12/26/46</i>	IV	1.11	1.53	1.22	
	<i>1/7/47</i>	IV	1.05	2.07	1.41	
	<i>6/26/47</i>	IV	0.94	1.67	1.14	
E. S.	<i>6/19/50</i>	VI	1.00	1.00	1.00	82
	<i>8/28/50</i>	VI	1.44	1.37	1.39	76
S. W.	<i>1/8/48</i>	II	1.00	1.00	1.00	20
	<i>1/22/48</i>	IV	1.36	0.18	0.61	2
	<i>3/3/48</i>	IV	1.74	0.21	0.78	3
	<i>4/28/48</i>	IV	1.54	0.30	0.66	2
	<i>2/10/49</i>	IV	1.12	0.29	0.60	
	<i>5/25/50</i>	V	1.56	0.081	0.62	
	<i>10/13/52</i>	IV	1.27	0.046	0.51	
	<i>1/5/53</i>	IV	1.12	0.031	0.43	
D. Y.	<i>7/15/46</i>	IV	1.00			
	<i>7/23/46</i>	IV	1.33			
	<i>12/11/46</i>	IV	0.84			

<sup>1</sup> The date of the reference dose for srd is in italics.<sup>2</sup> For these patients, measurements over the thyroid include radiation from metastases in the neck or upper chest and hence are high by an indeterminate amount.<sup>3</sup> Thyroidal accumulation of radioiodine impossible to determine.

TABLE V: EFFECT OF THYROIDECTOMY ON SPECIFIC RADIATION DOSE (SRD)

Period	Number of Doses		Number of Patients	
	In-creased srd	De-creased srd	In-creased srd	De-creased srd
$I^{131}$ Uptake (0-2d)	9	1	5	1
$I^{131}$ Release (after 2d)	2	10	1	5
Total irradiation time	2	7	1	2

iodine therapy and the onset of leukemia.<sup>5</sup>

#### EFFECT OF THYROIDECTOMY ON SRD

The effect of thyroidectomy on radiation delivered to the blood of 5 patients (B. A., A. Bl., J. F., R. M., L. O., and S. W.) was studied. For these patients, blood curves were available on the  $I^{131}$  dose employed to effect a radioiodothyroidectomy and on a total of 13 post-thyroidectomy therapeutic doses. Blood radioiodine concentrations were determined for periods of four to twenty-three days following  $I^{131}$  administration.

The srd for each dose was determined for three periods: (a) the period of radioiodine uptake by the thyroid, which we have taken as the initial forty-eight hours after  $I^{131}$  ingestion; (b) the period of radioiodine release by the thyroid, *i.e.*, the interval following the initial two days; (c) the total time of irradiation. For every patient and for each of these three intervals, a comparison was made of the srd delivered by the thyroidectomizing dose and by subsequent therapeutic doses of  $I^{131}$ . Only differences in srd exceeding 15 per cent were considered to be significant.

Table IV lists the srd on each dose relative to that delivered for the given time interval on the reference dose, the date of which is italicized.

Changes during the first period, the uptake phase, primarily reflect changes in the pattern of iodide removal from the blood by the thyroid gland. A rise or fall during the second period is related to a change in the pattern of release of  $I^{131}$  into the blood stream from the thyroid.

<sup>5</sup> Since this paper was submitted for publication, subacute myeloid leukemia developed in another patient in our series (B. L.) after five years of radioiodine during which a total of 1,600 mc of  $I^{131}$  was received.

The third value indicates changes in the overall pattern.

The results of this study are presented in Table IV and summarized in Table V. They show that the blood radioiodine concentration, and hence the associated srd, is nearly always lower during the uptake period of a thyroidectomizing dose than during the same interval following a therapeutic dose to the same patient after the thyroid has been ablated. This phenomenon can be explained by consideration of the metabolism of the administered radioiodide. Radioiodide clearance from the blood is performed primarily by the thyroid gland or functioning thyroid metastases and by the kidneys. When the thyroid gland is removed, the administered radioiodide will remain in the blood for a longer period, thus increasing the  $I^{131}$  concentration and, secondarily, the radiation delivered to the blood.

If all other factors, especially renal function, remain unchanged, and if uptake by metastases is negligible relative to that of the thyroid gland, it can be shown by consideration of the thyroidal and renal radioiodide clearance rates that the ratio

srd for initial 2 days after pre-thyroidectomy  $I^{131}$  dose  
srd for initial 2 days after post-thyroidectomy  $I^{131}$  dose

is approximately equal to the difference between 100 per cent and the per cent of the pre-thyroidectomy dose taken up by the thyroid gland at one day. Considering the relatively large experimental uncertainties inherent in the comparison, very rough agreement with this expectation has been observed.

This two-day increase in blood radioiodine concentration is partially responsible (26) for an increased  $I^{131}$  uptake by thyroid metastases, which has been observed (27, 28) to occur following thyroidectomy.

In contrast to the results during the uptake period, we find that during (b), the release phase of a thyroidectomizing dose, the srd is higher, in most cases, than that delivered during this phase of a therapeutic dose subsequently administered to

the same patient. This finding is consistent with the following hypothesis: In the presence of the normal thyroid, much of the circulating blood radioiodide will be removed initially by the gland and eventually released into the blood as protein-bound radioiodine, thus elevating or maintaining the blood  $I^{131}$  level for a considerable time. Following thyroidectomy, however, there will be no such release of protein-bound  $I^{131}$  into the blood, and the radiation will tend to be less.

On the other hand, following thyroidectomy, the blood levels of  $I^{131}$  during the release phase may be as high as, or higher than, during the release phase of the thyroidectomizing dose. Such a case could be explained by occurrence of one or both of the following mechanisms: (a) the hormonal synthesizing function of all the metastases might become as great or greater than that of the original thyroid gland; (b) the considerable decrease in the size of the pool of stable iodine in the body would cause an increase in the specific activity of  $I^{131}$  retained in the metastases and hence an increased  $I^{131}$  content of a given amount of thyroid hormone secreted. One might expect that in such a case the blood levels for succeeding doses will vary with the change in the functional status of the thyroid metastases and their total  $I^{131}$  content.

As shown in Table IV, we have found no marked change in the total srd delivered during the irradiation following a thyroidectomizing dose and the total srd following subsequent doses of  $I^{131}$ . This constancy of the srd results from the reversal, at about two days, of the relative magnitudes of the blood radioiodine concentration curves for pre-thyroidectomy and for post-thyroidectomy doses of  $I^{131}$ .

#### CHANGES IN SRD DURING COURSE OF RADIOIODINE THERAPY

Since the srd depends on the blood radioiodine concentration, one might *a priori* expect some changes in srd as therapy proceeds in a given patient. The

blood radioiodine curves on successive doses to a group of metastatic thyroid carcinoma patients (A. Be., B. Br., J. F., B. N., S. S., M. S. and S. W.) extensively treated with radioiodine were analyzed for a possible significant change in the srd as therapy progressed. The data in Table IV do not reveal such a trend.

For 3 hyperthyroid patients in Group VI, without carcinoma (M. E., S. M., and E. S.), for whom the srd's were calculated on successive therapeutic doses, the srd on the second therapeutic dose was from 20 to 50 per cent higher than on the first therapeutic dose.

A possible explanation for this unanticipated rise in srd may be a decrease in the amount of  $I^{127}$  in the thyroid gland produced by the preceding therapy, causing a rise in the specific activity of the thyroidal radioiodine. In spite of small decreases in the total rate of secretion of thyroid hormone, there would be an increased  $PBI^{131}$  concentration in blood due to the rise in the specific activity of the hormone.

#### SRD, THYROID FUNCTION, AND BIOLOGICAL HALF-LIFE

The srd is essentially a measure of the time integral of the radioiodine concentration in the blood. In order to determine whether the srd is correlated with thyroid function, we have analyzed the srd resulting from 10 therapeutic doses to 7 non-cancer patients with hyperthyroidism, all of whom had a twenty-four-hour thyroid uptake exceeding 55 per cent of the administered  $I^{131}$ . Hyperthyroid patients were chosen because of technical simplicity. Since the srd depends on the radioiodine concentration in the blood, and since after the first two days following ingestion of the dose the blood  $I^{131}$  is primarily protein-bound iodine, having been previously taken up and released by the thyroid gland, a correlation was sought among: (a) the srd delivered after the initial forty-eight hours, (b) the biological half-life of the isotope within the thyroid gland, and (c) the one-day thyroid uptake.

TABLE VI: SRD, BIOLOGICAL HALF-LIFE, AND THYROID UPTAKE OF  $I^{131}$  IN HYPERTHYROID PATIENTS

Patient	Date of Dose	SRD after Initial 2 Days (rep/100 mc)	Biological Half-Life (days)	24-Hour Thyroid Uptake (%)
E. S.	6/19/50	19	60	82
E. S.	8/28/50	26	40	76
A. Ols.	6/27/50	53	22	60
S. D.	4/19/48	72	20	88
E. M.	3/16/51	82	14	79
S. M.	6/1/50	97	10	88
M. E.	9/23/50	108	9	55
S. M.	9/6/50	112	8	72
R. B.	11/17/52	165	28	98
M. E.	1/21/51	187	3	64

For these 7 hyperthyroid patients (Table VI), the srd from two days to infinity is, with one exception, inversely related to the biological half-life of the isotope. This observation is in agreement with the expectation that the blood  $I^{131}$  concentration will rise with an increased rate of release of the isotope from its depot within the thyroid gland.

Table VI shows no decided correlation of srd during the release phase with twenty-four-hour uptake of radioiodine.

In an extension of this study, an investigation of the biological half-life of  $I^{131}$  in the thyroid gland following 124 therapeutic doses to hyperthyroid patients has shown no decided correlation of the biological half-life with the initial per cent uptake of the isotope, with the size of the thyroid, or age and sex of the patient.

#### DISCUSSION

We have studied the radiation dose delivered to the blood during various stages of radioiodine therapy and the concomitant injury to the hematopoietic system. The patients with metastatic thyroid carcinoma were divided into various categories or groups in relation to the amount of remaining functioning thyroid tissue in order to reveal the influence of this tissue on the blood radiation dose. The diagnostic as well as the therapeutic significance of blood radioiodine concentration with the resulting srd was considered. Approximate values for generalized body radiation have been estimated.

What is the proper measure of blood radiation dosage? In view of the wide variation observed in the radiation delivered [rep] by the same amount of radioiodine, it is certainly inaccurate to consider the number of millicuries of  $I^{131}$  administered to a patient as the sole measure of probable blood radiation dosage. The specific radiation dose [rep/100 mc] permits us to compare the radiation efficiency of successive doses of the isotope to a given patient, as well as for various types of patients.

Since it would seem that the srd during the first two days after ingestion of  $I^{131}$  is inversely related to the functional level of thyroid tissue and subsequently is directly related to its functional level, we will, for simplicity, limit ourselves in this discussion, to srd's for the interval subsequent to the first two days.

The srd has been determined during radioiodothyroidectomy and subsequent  $I^{131}$  therapy of metastatic thyroid carcinoma, and also during therapy of hyperthyroid patients. In general, one can state that there is a marked variation of srd among the above groups as well as among patients within these groups. The hyperthyroid group has a higher average srd than the other categories. Within the hyperthyroid group, the correlation between degree of thyroid function ( $I^{131}$  uptake) and srd is not clearly evident. Within the thyroidectomized cancer group, our overall impression is that the low srd goes with little or no functioning tumor tissue, the high srd with large amounts of highly functioning tumor tissue. This seems to hold only in the extreme, well defined cases. Most patients in our series however, fall between the extremes. Moreover, the exact mass of tumor tissue and the degree of function are difficult to evaluate.

The study of blood radioiodine concentration and resulting srd in our patients with metastatic thyroid carcinoma proved to be of great practical value both from the diagnostic and therapeutic points of view.



Diagnostically: (a) In thyroidectomized patients, a high level of blood radioiodine concentration from two days on speaks for the presence of functioning metastases, with a rapid iodine turnover rate. (b) Conversely, a low level of blood radioiodine concentration speaks for either scarcity or absence of functioning tumor tissue. (c) In totally thyroidectomized patients, if the administration of a therapeutic dose is followed by a delayed rise in blood  $I^{131}$  concentration (29), we can be reasonably sure of the presence of functioning thyroid carcinoma metastases. The absence of such a rise does not necessarily indicate the absence of such metastases. The presence of significant amounts of plasma protein-bound radioiodine should offer strong confirmatory evidence for tumor function.

In therapy: (a) Our analysis and findings indicate that radioiodine therapy results in relatively low generalized body radiation, on the average about 30 rep/100 mc  $I^{131}$ . With our radioiodine dosage, the likelihood of delivering a fatal generalized radiation dose seems remote. (b) The total srd is relatively constant for a given patient as therapy progresses, the variation being certainly less than a factor of 2. This finding points to the probable existence of factors other than tumor mass and tumor function that participate in the control of the srd. (c) If a preliminary test dose of  $I^{131}$  results in a high srd, one should be very conservative in determining the maximum individual therapeutic doses of the isotope, since the high srd means high radiation efficiency, and consequently high radiation dosage. (d) A significant difference between the srd after tracer and after therapeutic doses of  $I^{131}$  to a patient with functioning thyroid tumor tissue should indicate some radioiodine destruction of this tissue.

It should be restated that the radiation contributed by the thyroid gland to the body radiation was not included in our calculations, but from Bush's findings we have estimated that for a euthyroid patient this source could contribute not more than 3 r/100 mc  $I^{131}$ . Moreover, our

patients were usually thyroidectomized before the intense radioiodine therapy was undertaken, and the metastases were, as a rule, of a lower functional order than the thyroid gland and would therefore contribute even less to body radiation than the equivalent mass of non-neoplastic thyroid tissue.

The low total-body irradiation together with the relatively long time during which this radiation is delivered is probably responsible for the low radiation toxicity of a single therapeutic dose of radioiodine as evidenced by the hematologic studies. On the other hand, cumulative radioiodine doses can result in considerable toxicity and irreversible changes in bone marrow. Further studies are therefore indicated to evolve methods for protecting the hematopoietic system from radiation as well as methods for increasing the biological half-life of the isotope within the tumors.

#### SUMMARY

The blood radioiodine concentration was determined for periods of one to thirty-five days following ingestion of 69 oral therapeutic doses of  $I^{131}$  by 26 patients with metastatic thyroid carcinoma.

Calculations are presented by means of which the specific radiation dose [rep/100 mc] to the blood and the total blood radiation may be computed from the area under the curve of specific blood radioiodine concentration [ $\mu\text{c/gm.}/100 \text{ mc } I^{131}$ ] vs. time. It is shown that the generalized body radiation is about 50 per cent of that received by blood.

The specific radiation dose (srd) delivered to the blood has ranged from 20 to 182 rep/100 mc, with a mean value of  $56 \pm 34$  rep/100 mc. The maximum blood radiation due to a single dose of  $I^{131}$  was calculated to be 316 rep after administration of 208 mc.

The largest single dose of  $I^{131}$  in our series was 208 mc. The largest total amount of radioiodine administered to a patient was 2,300 mc, given over a period of two and a half years. Another



patient has received 2,000 mc during the last five years.

Except for an occasional temporary leukopenia, no untoward effects followed a single therapeutic dose of  $I^{131}$ . No permanent injury of the hematopoietic system has been observed in the 2 patients who received 2,300 and 2,000 mc. On the other hand, in 2 of 14 patients who received extensive radioiodine therapy, persistent severe leukopenia developed after delivery of about 175 and 1,600 rep to the blood. A third patient in this group died with subacute myelogenous leukemia, after a cumulative blood radiation dose of about 600 rep.<sup>6</sup>

It was observed that the blood radioiodine concentration during the first two days after ingestion of  $I^{131}$  is lower following a radiation thyroidectomizing dose than following subsequent therapeutic doses to the same patient after thyroidectomy. However, after the initial forty-eight hours, the  $I^{131}$  concentration is usually lower if the patient no longer has a thyroid gland.

The diagnostic and therapeutic significance of the specific radiation dose is discussed.

#### ADDENDUM

The Seventh International Congress of Radiology (Copenhagen, 1953) has established the "rad" as the unit quantity of radiation. It corresponds to an energy absorption of 100 ergs/gm. Assuming that the average energy absorption in the body of 1 r of gamma radiation from  $I^{131}$  is 93 ergs/gm, the radiation doses calculated in this paper may be converted from rep to rad by multiplying by 0.93.

**ACKNOWLEDGMENTS.** The excellent technical assistance of Mr. Morris Hodara contributed much to this study.

The authors appreciate the constructive criticisms and helpful suggestions in preparation of the manuscript made by Drs. G. A. Andrews, S. Berson, M. Brucer, J. H. Lawrence, L. Marinelli, S. Melamed, N. B. Myant, T. H. Oddie, E. E. Pochin, E. Quimby, Shields Warren, and R. S. Yalow.

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<sup>6</sup> For reference to another case of subacute myeloid leukemia developing later in this series, see Footnote 5, page 808.

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## SUMARIO

## La Dosis Sanguínea de Irradiación Durante la Radiyodoterapia de las Metástasis Tiroideas del Carcinoma

La concentración sanguínea de radioyodo fué determinada durante períodos de uno a treinta y cinco días consecutivamente a la ingestión de 69 dosis terapéuticas orales de  $I^{131}$  por 26 enfermos que tenían metástasis carcinomatosas en el tiroides.

Preséntanse cálculos por medio de los cuales cabe computar la dosis específica de irradiación (rep/100 mc) recibida por la sangre y la irradiación total de la sangre por el área comprendida en la curva de concentración sanguínea específica de radioyodo ( $\mu\text{c/gm.}/100 \text{ mc de } I^{131}$ ), comparada con el tiempo. Calcúlase que la irradiación generalizada del cuerpo representa aproximadamente 50 por ciento de la recibida por la sangre.

La dosis específica de irradiación llevada a la sangre ha fluctuado de 20 a 182 rep/100 mc, con un valor medio de 56-34 rep/100 mc. La irradiación sanguínea máxima debida a una sola dosis de  $I^{131}$  fué computada en 316 rep después de la administración de 208 mc.

La mayor dosis aislada de  $I^{131}$  en la serie fué de 208 mc. La cantidad total máxima de radioyodo administrada a un enfermo ascendió a 2,300 mc, administrado durante un período de dos años y medio.

Exceptuada alguna que otra leucopenia temporal, no hubo efectos contraproducentes después de una sola dosis terapéutica de  $I^{131}$ . Tampoco se observó lesión permanente del sistema hematopoyético en los 2 enfermos que recibieron 2,300 y 2,000 mc, respectivamente. En cambio, en 2 de 14 enfermos que recibieron persistente y extensa radiyodoterapia, se presentó leucopenia grave después de llevar unos 175 y 1,600 rep a la sangre. Otro enfermo de este grupo falleció de leucemia mielógena, a continuación de una dosis sanguínea acumulativa de unos 600 rep de irradiación.

Observóse que la concentración sanguínea de radioyodo durante los dos primeros días consecutivos a la ingestión de  $I^{131}$  es menor después de una dosis tiroideotomizante de irradiación que después de dosis terapéuticas subsiguientes administradas al mismo enfermo después de la tiroidectomía. Sin embargo, pasadas las primeras cuarenta y ocho horas, la concentración de  $I^{131}$  suele ser menor si el enfermo ya no tiene tiroides.

Discútese la importancia diagnóstica y terapéutica de la dosis específica de irradiación.

## Roentgen Appearance of Gastric Invasion from Carcinoma of the Colon<sup>1</sup>

ARNOLD L. BACHMAN, M.D.

OVER A PERIOD OF a year, 4 cases of primary carcinoma of the transverse colon were encountered, in each of which the stomach was invaded by direct extension. Although the degree of gastric involvement varied, the roentgen picture in these cases was sufficiently similar and characteristic to suggest the diagnosis.

Discussions of gastric involvement by adjacent colon carcinoma are usually included in the literature under the heading gastrocolic fistula, with emphasis upon the fistulous tract and its complications (5, 12, 15). The various causes of gastrocolic fistulas are enumerated, and the clinical syndrome and therapeutic approach are reviewed, but no specific attention is given to the roentgen diagnosis of the different types of fistula. A gastrocolic communication is so frequently observed, however, in cases of involvement of the stomach by carcinoma of the colon that a brief comment appears warranted.

Most commonly gastrocolic fistulas are found in association with (a) carcinoma of the stomach, (b) carcinoma of the colon, or (c) as a complication of gastroenterostomy. Less frequently they are due to (d) other malignant neoplasms in the abdomen, (e) penetrating abdominal wounds, such as stab and gunshot, (f) intra-abdominal abscess, (g) syphilis and tuberculosis. During the period when gastroenterostomy was popular for the treatment of peptic ulcer, it was not unusual to encounter a gastrocolic fistula as a sequel to that procedure (12, 15). Today, however, carcinoma appears to be the most frequent cause (3, 4, 5, 6). Analysis of recorded cases also indicates that primary carcinoma of the stomach extending to the colon is seen somewhat more often than carcinoma of the colon extending to the stomach (3, 6).

In cases of cancer, the fistula is part of the malignant process, and tumor cells form the lining of the tract (15). The flow of alimentary contents through the fistula is usually bidirectional; it may, however, be unidirectional, the direction varying from case to case (4, 5, 6). Fistulous tracts between other organs have also been reported as complications of intra-abdominal carcinoma (4, 14, 15, 16). Of these, jejunocolic and ileocolic fistulas are probably the most common.

Although the roentgen findings in gastrocolic fistula due to colonic cancer have not been described in detail, several cases have been reported of carcinoma of the colon simulating carcinoma of the stomach (9, 10). In addition, a number of articles include reproductions of roentgenograms of cancer of the colon invading the stomach, showing fistulous tracts (2, 8, 17). Practically all of these roentgenograms demonstrate one of the characteristics shown by the cases to be reported here. Indeed, such a study serves to confirm the constancy of the roentgen pattern in this condition.

Table I gives the details on the 4 cases of cancer of the colon with gastric invasion forming the basis of this paper, with references to the accompanying roentgenograms.

### DISCUSSION

The distal three-fifths of the transverse colon lies immediately below and very slightly posterior to the greater curvature of the stomach. This portion of the colon and the greater curvature are connected by a short segment of greater omentum known as the gastrocolic ligament (Fig. 7). Thus, the anatomical relationship is such that the stomach can be directly invaded across the short gastrocolic omentum only from

<sup>1</sup> From the Department of Roentgenology, Francis Delafield Hospital, New York, N. Y. This work was supported in part by an institutional grant from the American Cancer Society to the College of Physicians and Surgeons, Columbia University, N. Y. Accepted for publication in October 1953.

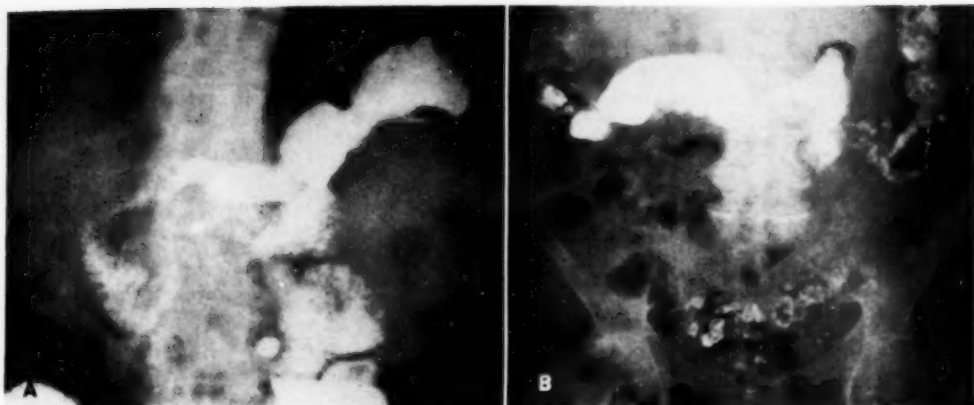


Fig. 1. Case I. A. Smooth, sharply outlined, crescentic indentation in greater curvature of pars media. An ill defined soft-tissue density containing an irregular gas pocket is seen just below the gastric indentation. The jejunum is displaced to the right by this soft-tissue mass.

B. Barium in transverse colon five days after oral administration. Note irregular constriction of distal transverse colon which is continuous with a barium- and gas-outlined abscess cavity. This cavity lies in the large soft-tissue mass seen in A.

the region of the mid-transverse colon to the splenic flexure. Since this portion of the colon is adjacent to the somewhat posterior aspect of the greater curvature, it is on the latter border that the filling defect is characteristically found. The entire length of the greater curvature is susceptible to invasion. At the proximal end, extension of the neoplasm from the region of the splenic flexure is manifest near the fundus. Distally, mid-transverse colon lesions invade the greater curvature in the antral region. It is therefore essential to study the colon in all cases in which filling defects are found on the greater curvature. This point has also been stressed by other observers (9, 10).

The appearance of the gastric extension is determined by the degree of invasion. This variation is well illustrated in the 4 cases presented. An arbitrary, but practical, division into several stages may be made:

1. Simple crescentic indentation on the greater curvature as a result of involvement of serosa and muscularis only (Fig. 1A).

2. Large crescentic defect with deep ulceration, but no fistula visualized (Figs. 2A and 3A). An actual fistula may be present, but not demonstrated in the gastro-

intestinal series (as in Cases II and III).

3. Crescentic defect with ulceration and fistula formation apparent (Fig. 6).

4. Any of the above findings plus gross displacement of the stomach to the right and slightly anteriorly by the large mass (Figs. 1A and 5B).

Examples of these different stages may be observed in the roentgenograms reproduced in the articles on gastrocolic fistulas mentioned above (2, 9, 10, 17). The involvement of the stomach begins at the serosa and gradually bulges inward, usually producing a circumscribed defect which makes a rather sharp angle with the contour of the adjacent normal greater curvature. The acuity of the angle appears to increase with greater mural indentation and intrinsic wall involvement. The margin of the defect is generally sharply circumscribed. Multiple, polypoid, infiltrating, or irregular filling defects in the gastric silhouette have not been observed or reported. The mucous membrane of the stomach is simply flattened by the mass extending inward from the muscular layer except for the necrotic area forming the opening of the fistulous tract. As a result, rugae are usually absent (completely flattened or destroyed) only in the center of the bulging defect.



TABLE I: SUMMARY OF FOUR CASES OF CARCINOMA

Case No., Name, Sex, and Age	History and Physical Findings	Roentgenologic Findings
Case I, F. L., F, 73	Weakness, anorexia, and diarrhea for two months. Loss of 100 lb. in six months. Firm, large, movable, tender mass in left upper quadrant.	Preliminary film of the abdomen showed several irregular, mottled air shadows surrounded by a zone of soft-tissue density in left upper quadrant. Barium meal study revealed a crescentic indentation exactly on greater curvature of stomach in pars media, due to pressure from the gas-enclosing soft-tissue mass (Fig. 1A). No mucosal destruction or ulceration in the crescentic defect. Intestinal motility markedly impaired. At twenty-four hours the barium had arrived at the ascending colon. At three days it had reached only the mid-transverse. At five days the distal transverse and splenic flexure were outlined (Fig. 1B). There was asymmetric narrowing of the transverse colon near the splenic flexure, and irregular collections of barium extended into the gas-filled soft-tissue density in this region. The appearance was that of an extensive intrinsic lesion in the transverse colon accompanied by a large local abscess adherent to the stomach.
Case II, G. G., F, 54	Increasing anorexia, occasional tarry stools and postprandial pain for eight months. Weight loss of 40 lb. Suggestive mass felt in epigastrium and left upper quadrant.	Barium meal revealed a huge semilunar defect on greater curvature of pars media (Fig. 2A), in the center of which was a large ulcer crater. The rugal folds were obliterated in the center and flattened at the margins of the defect. However, the rugae nowhere showed nodulation or irregular destruction.
Case III, R. H., F, 70. Courtesy of Dr. John H. Mosely, Roentgenologist, Sydenham Hospital, New York	Increasing weakness and vertigo for several months. No gastrointestinal symptoms. No abdominal masses palpable.	Barium meal study revealed a huge, smooth crescentic indentation defect on greater curvature of pars media containing a large central ulcer crater (Fig. 3A). Barium enema study showed a segment of irregularly narrowed colon with destruction of mucosa in the distal transverse colon (Fig. 3B).
Case IV, P. P., M, 59	Anorexia, weakness and left upper quadrant pain for two months. Loss of 15 lb. Large, firm, multinodular, movable mass in left upper quadrant.	Barium enema study (Fig. 5A) disclosed a huge, irregular filling defect and obstruction with destruction of mucosa in splenic flexure. Barium meal examination (Fig. 5B) showed a large, smooth, crescentic indentation defect on greater curvature of pars media, with a large ulcer crater in its center. Twenty-four-hour study showed stomach empty and barium in ascending colon. At forty-eight hours (Fig. 6A) barium was in distal colon. The splenic flexure neoplasm was outlined. In addition, a fistulous tract into the stomach was seen for the first time.

More peripherally, the rugae increase in size to normal or even exaggerated width.

In the more advanced cases a large, irregular, deep ulcer niche is seen in the center of the defect, representing the gastric opening of a cologastric neoplastic fistula (Figs. 2A, 3A, and 5B). The tract itself may not be demonstrated. The flow may be unidirectional or the fistula may be only intermittently patent. In one case (Case IV) an initial barium enema study and a barium meal failed to demonstrate the fistula. It was only at forty-eight hours after the meal that the barium reached the transverse colon and

passed through the fistula into the stomach. It is therefore important to follow the barium to the colonic ampulla by serial examinations in all cases with suggestive gastric lesions, even though passage through the colon may be greatly delayed. In Case I it required five days for the barium meal to reach the splenic flexure, but information of paramount importance was obtained at this time. While the fistulous tract may be difficult to demonstrate in some cases, in others it may be markedly patulous. Senff (13) reports a barium enema examination in a case of gastrocolic fistula due to cancer, during



## OF COLON WITH EXTENSION TO STOMACH

Laboratory Data	Operative Findings	Follow-Up
Hgb. 5 gm. R.B.C. 1,950,000 per c.mm. Stool: 4 plus benzidine	Signs of viscus perforation appeared and an exploratory operation was performed. Large carcinoma of transverse colon with minute perforation and adjacent gas-containing walled-off abscess disclosed. Limited resection and colostomy done because of poor condition of patient.	Improvement for several months; recurrence and death nine months postoperatively.
Hgb. 3.8 gm. R.B.C. 2,790,000 per c.mm. Stool: 1 plus guaiac.	Block excision of tumor-bearing area: partial gastrectomy, partial colectomy, splenectomy, omentectomy, and partial pancreatectomy. Large carcinoma of transverse colon invading across the gastrocolic omentum to involve the greater curvature of stomach and bulge into lumen (Fig. 2B). Mucosa over apex of bulging mass completely destroyed. More marginally, the folds were flattened but not nodular. Gastrocolic fistula present. Sixty-four lymph nodes cleared and none showed metastasis.	Alive and well without recurrence twenty-seven months postoperatively.
Hgb. 6.3 gm. R.B.C. 2,350,000 per c.mm.	Large carcinoma of distal transverse colon extending across gastrocolic omentum to involve pars media of stomach removed en bloc. Opened stomach (Fig. 4) showed a large, smooth mass bulging into lumen. Mass covered by smooth glistening mucosa except at apex where three deep ulcerations were present, corresponding to openings of sinus tracts. Two uninvolved lymph nodes found.	Discharged improved. No follow-up.
Hgb. 14.3 gm. R.B.C. 4,980,000 per c.mm.	Large carcinoma of splenic flexure with a bulging extension into the greater curvature of the stomach and cologastric fistula (Fig. 6B). Block excision of entire tumor-bearing area. Forty lymph nodes cleared and negative for metastases.	Alive and well without recurrence eighteen months postoperatively.

which the opaque fluid entered the stomach in large quantities. The barium ascended to the cardia and entered the esophagus in such amounts that the roentgenogram was interpreted as showing a large hiatus hernia. While there are many variations in the anatomic appearance and function, it is highly desirable that the fistula be demonstrated because of its diagnostic importance.

Several gastric lesions must be considered in the differential diagnosis:

(1) *Intramural neoplasms* such as leiomyoma and leiomyosarcoma, either with or without ulceration, may produce a roent-

genologic picture very similar to that of gastric extension from colon carcinoma. Indeed, if the primary intramural tumor is in the greater curvature, the appearance may be indistinguishable (7). This may be readily understood when it is realized that the gastric extensions are also in essence intramural tumors (see Figs. 2B, 4, and 6B). The demonstration of a fistulous tract, however, is a significant factor against the diagnosis of primary intramural tumor. In addition, many intramural gastric tumors occur in sites other than along the greater curvature. In such instances, because of location,

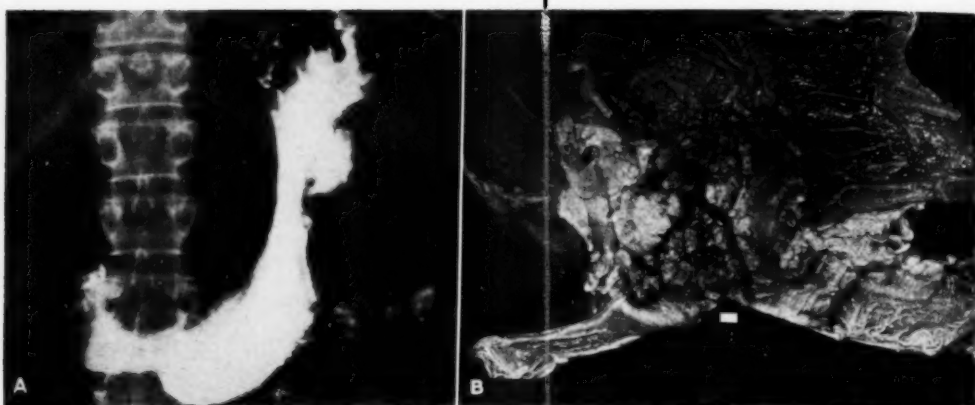


Fig. 2. Case II. A. Large semilunar indentation in the greater curvature of the pars media. Note huge ulcer crater projecting outward from near the center of the crescentic defect. Visualized mucosal folds coarsened but not nodular.

B. Resected specimen showing transverse colon below, spleen above and to left, stomach above and to right. Large tumor of transverse colon invading the stomach from without. Note bulge into gastric lumen; ulcer and fistula in center of bulge.

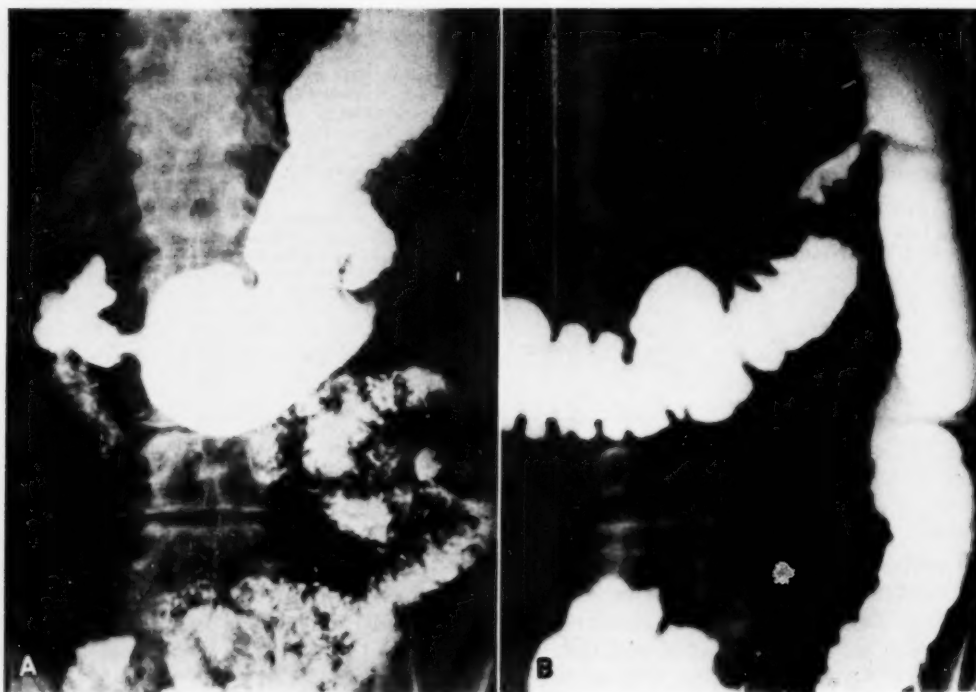


Fig. 3. Case III. A. Large, comparatively smooth crescentic indentation in greater curvature of pars media. Huge ulcer crater seen in center of the defect.

B. Primary carcinoma of distal transverse colon. Note irregular narrowing of lumen, destruction of mucosa, and sharp transition to adjacent normal colon.

differentiation may be made without difficulty.

(2) *Primary neoplasms of the greater*

*curvature of the stomach such as carcinoma, lymphosarcoma, and Hodgkin's disease present a different appearance from that*

seen in invasion of the stomach by colonic cancer. These tumors are usually not sharply circumscribed, may show an overhanging shelf, are not of regular crescentic shape, and usually demonstrate irregular destruction of the gastric mucosa rather than simple flattening. It appears advisable, nevertheless, to perform a barium enema study in all lesions involving the greater curvature.

(3) *Other intra-abdominal neoplasms* may press upon the stomach and cause crescentic defects, rarely with fistulas. However, since their anatomic relationship to the stomach is not the same as between the stomach and transverse colon, the defects would probably not be localized to the greater curvature. For example, pan-



Fig. 4. Case III. Resected stomach. Note mass bulging into lumen from without. Most of overlying mucosa is intact, but with rugal markings completely flattened. In the center, the mucosa is destroyed by invasion and the opening of the huge ulcer crater is observed.

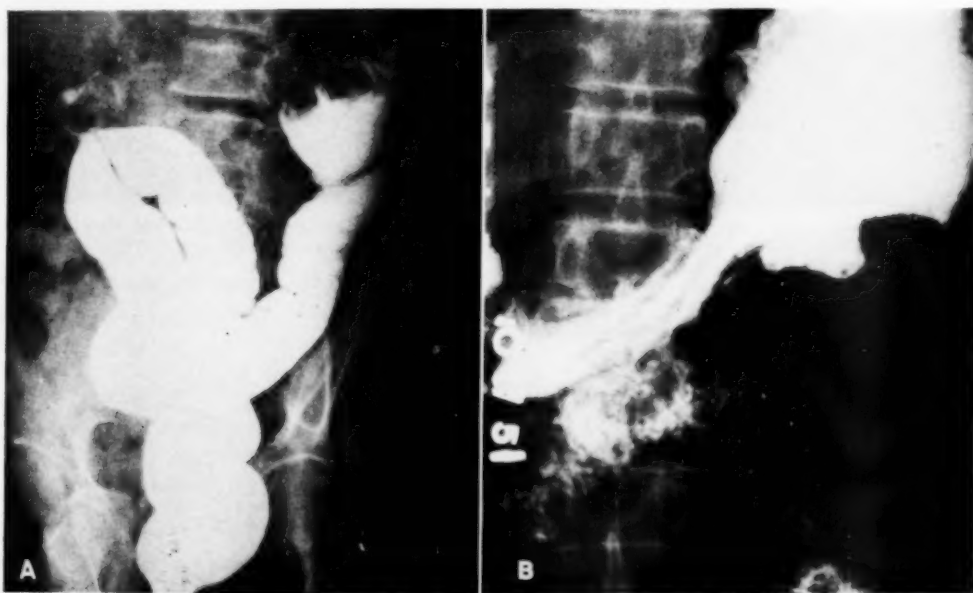


Fig. 5. Case IV. A. Large, irregular obstructing carcinoma of the splenic flexure. B. Crescentic indentation in greater curvature of pars media. Large ulcer crater in center of indentation.

creatic tumors cause pressure chiefly upon the posterior gastric wall and lesser curvature; liver tumors usually involve the lesser curvature; splenic pressure is more diffuse, affecting a more anterior aspect of the greater curvature, and the splenic shadow itself can usually be delineated.

(4) *Gastrocolic fistulas due to other causes* than invasion of the stomach by a cancer

of the colon may be either non-neoplastic or neoplastic in origin. Postoperative and post-traumatic non-neoplastic fistulas do not produce a filling defect in the stomach and show no evidence of a mass (12). In addition, there will be the history of previous trauma or operation for ulcer. Other neoplastic gastrocolic fistulas include primarily those due to carcinoma of



Fig. 6. Case IV. A. Barium in colon forty-eight hours after oral administration. Note irregular carcinomatous constriction in transverse colon and small amounts of barium in the stomach indicating a cologastric fistula. The fistulous tract is faintly visualized.

B. Resected specimen. Note the bulging of the mass into the gastric lumen. The opening of the fistulous tract into the gastric crater at the center of the bulge is also clearly shown.

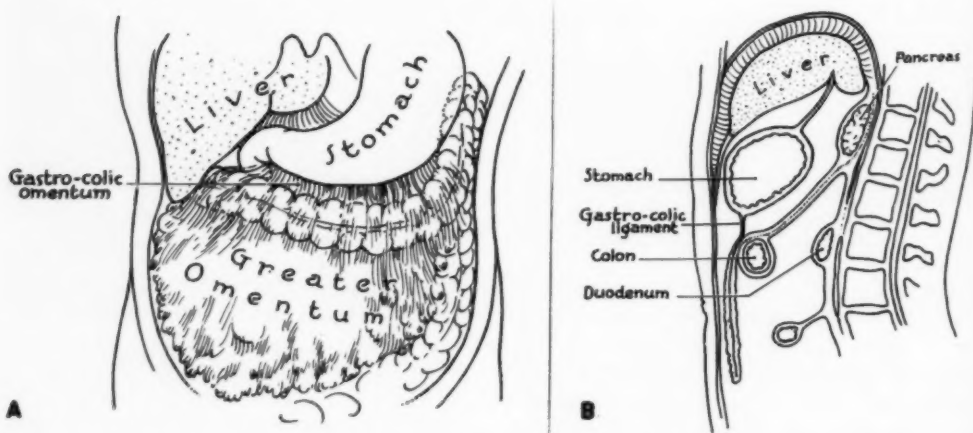


Fig. 7. A. Diagram of coronal section of upper abdomen showing extent of gastrocolic omentum and relationship of stomach to transverse colon.

B. Diagram of sagittal section showing cologastric relationship.



the stomach extending to the transverse colon. In these cases the roentgen appearance of the stomach resembles more closely that of primary carcinoma than of intramural tumor (1, 11). It is also my impression that the fistulous tracts associated with the primary gastric lesions may be larger, more widely patent and more easily demonstrated by barium meal study. Nevertheless, it seems probable that in an occasional case it may be impossible from the roentgenogram to state certainly whether the primary tumor is in the colon or stomach.

Several clinical features are worthy of mention. Despite the origin of the tumor in the colon, the spread to the stomach may result in symptoms which are predominantly gastric in nature. These upper gastrointestinal symptoms plus the finding of a gastric lesion roentgenologically may lead the unwary to halt the investigation without examining the colon. As a result, the true intra-abdominal condition is not realized and the preoperative preparation may be inadequate for the more extensive surgical procedure required.

In 3 cases (Cases II, III, and IV), there were huge masses with extensive spread from the colon to the adjacent gastrocolic omentum and stomach. Despite the large size and local extent of the carcinomatous masses, there was no evidence of lymph node or liver metastases. In 2 of these cases the specimens were carefully cleared and a large number of nodes examined. These patients are alive over eighteen and twenty-seven months respectively, without evidence of recurrence. The palliative result, at least, has been excellent. Vinci, McLeod, and LaBella (16) also state that such carcinomatous fistulas do not necessarily mean inoperable disease with widespread metastases. If distant metastases are not found on preoperative study, such cases are certainly worthy of exploration despite the large size of the intra-abdominal mass.

#### SUMMARY

The roentgenologic findings in 4 cases of

carcinoma of the colon with local extension to the stomach appear to conform to a pattern which is highly suggestive of the lesion. Depending upon the degree of gastric wall invasion, the roentgen examination may show: (1) a simple crescentic indentation on the greater curvature of the stomach, (2) a large crescentic defect with a deep central ulcer crater, (3) a defect with ulceration and a fistulous tract.

The radiographic differentiation from several other gastric lesions is discussed, and the pertinent literature reviewed.

The size of the intra-abdominal mass and the presence of a fistula are not contraindications to operative exploration in cases of neoplastic cologastric involvement. Three of the cases reported showed no lymph node, liver, or distant metastases at the time of operation. Two patients have remained well for more than eighteen and twenty-seven months, respectively, following surgery.

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#### SUMARIO

#### Aspecto Roentgenológico de la Invasión Gástrica por Carcinoma del Colon

Durante un período de un año, observáronse 4 casos de carcinoma primario del colon transverso, en todos los cuales el estómago había sido invadido por difusión directa. Aunque variaba la extensión de la invasión gástrica, el cuadro roentgenológico en estos casos era suficientemente similar y típico para sugerir el diagnóstico.

De acuerdo con el grado de invasión de la pared gástrica, el examen roentgenológico puede revelar: (1) una sencilla indentación semilunar en la curvatura mayor del estómago; (2) un gran nicho semilunar con un cráter profundo de úlcera en el centro; (3) un nicho con ulceración y trayecto fistuloso.

Las lesiones gástricas que exigen diferenciación de la invasión por carcinoma colónico comprenden: neoplasias intra-

murales, tales como leiomioma y leiomyosarcoma; neoplasias primarias de la curvatura mayor, tales como carcinoma, linfomasarcoma y enfermedad de Hodgkin; otras neoplasias intraabdominales que comprimen el estómago y producen nichos semilunares; fistulas gastrocólicas de origen traumático o debidas a carcinoma gástrico.

El tamaño de la tumefacción intraabdominal y la presencia de una fistula no constituyen contraindicaciones de la exploración quirúrgica en casos de invasión cologástrica por neoplasia. Tres de los casos descritos no presentaban metástasis linfoganglionares, hepáticas o remotas al operar. Dos enfermos han permanecido bien durante más de dieciocho y veintisiete meses, respectivamente, después de la operación.



# Intramural Hematoma of the Duodenum

## A Diagnostic Roentgen Sign<sup>1</sup>

BENJAMIN FELSON, M.D., and EMANUEL J. LEVIN, M.D.

**I**NTRAMURAL hematoma of the intestine is a condition in which, spontaneously or as a result of trauma, a localized collection of blood extravasates into the subserosal and interstitial tissues of the intestine. It has been described on a number of occasions as an unexpected finding at laparotomy or at autopsy, but a correct preoperative diagnosis has not been recorded. In 1948 Liverud (9) reported a case involving the jejunum adjacent to the ligament of Treitz, and included the only detailed roentgen description in the literature.

We have encountered 4 cases, in each of which the duodenum was predominantly affected. The roentgen findings, similar to those in Liverud's case, are so distinctive that we believe them to be pathognomonic of intramural hematoma of the duodenum.

### REPORT OF CASES

**CASE I:** G. D., an 18-year-old male, was admitted to Cincinnati General Hospital on Nov. 17, 1951, seven hours after being struck in the abdomen during a football game. He was momentarily prostrated by the injury, but felt well for the next few hours. Three hours after the injury, persistent dull upper abdominal pain developed, slowly increasing in intensity and accompanied by vomiting. There was no hematemesis or melena.

On admission, the temperature was 99°F., and pulse, respirations, and blood pressure were normal. Physical examination was negative except for tenderness in the upper abdomen and right flank. Hemoglobin was 14 gm., the white blood cell count 8,600, and serum amylase 646 Somogyi units. Urine was normal.

Flat and upright films of the abdomen on admission showed no free gas. The right psoas shadow was not visualized. Because of the possibility of a ruptured hollow viscus, a small amount of Lipiodol was given by mouth and followed for eight hours. Except for some delay in transit time, no abnormalities were seen.

On conservative management, the low-grade

fever and epigastric pain persisted. The white count rose to 14,000 and the serum amylase gradually fell to 124 units.

On Nov. 21, an upper gastrointestinal series was performed with barium. A small extrinsic defect on the greater curvature of the gastric antrum was noted, and the mucosal folds in the proximal duodenum appeared thickened. In the distal duodenum, near the ligament of Treitz, an intramural extramucosal type of defect was seen. The valvulae conniventes in this region were crowded together (Fig. 1, A and B). The roentgen findings were attributed to intramural inflammation or hemorrhage secondary to acute traumatic pancreatitis, possibly with perforation into the duodenum. The examination was repeated on Nov. 25 with similar findings.

Surgical exploration was undertaken on Nov. 27. A subserosal hematoma 20 cm. in length was found in the distal duodenum and proximal jejunum. There was also a large hematoma in the adjacent retroperitoneal space. The two hematomas communicated and together contained about 600 c.c. of liquid and clotted blood. The head of the pancreas was indurated and showed a small area of fat necrosis. The hematomas were evacuated and the abdomen closed.

The postoperative course was uneventful. On Dec. 8, a gastrointestinal series showed marked regression of the roentgen findings. The patient remained symptom-free during a follow-up period of seven months.

*Comment:* The clear-cut history of trauma in this case, the elevated serum amylase, and the striking roentgen changes in the duodenum incriminated the pancreas and led to an incorrect preoperative diagnosis of traumatic pancreatitis.

**CASE II:** R. F., a 9-year-old girl, was admitted to Cincinnati General Hospital on June 22, 1952, two days after injuring her abdomen in a fall. Upper abdominal pain appeared soon after the injury and became progressively more severe. It was accompanied by vomiting, but no hematemesis or melena.

On admission, the temperature was 100.4°F., pulse 104, and respirations 26. Blood pressure was normal. Physical examination was negative except

<sup>1</sup> From the Department of Radiology, University of Cincinnati College of Medicine, and the Cincinnati General Hospital. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13-18, 1953.



Fig. 1. Case I. Gastrointestinal series, Nov. 22, 1951.

A. Bucky film, showing small extrinsic pressure defect on greater curvature of prepyloric segment of stomach, thickened mucosal folds in the proximal duodenum, and intramural mass with crowded valvulae conniventes in the distal duodenum (arrow).

B. Spot film, showing the intramural defect (arrows).

for moderate upper abdominal tenderness and muscle guarding. Hemoglobin was 13 gm., the white blood cell count 17,800, with 90 per cent polymorphonuclear leukocytes, and serum amylase was normal. The urine was normal.

Flat and upright films of the abdomen showed no free gas. The right psoas shadow was poorly visualized, while the left showed a streak of lessened density along its lateral margin, suggesting retroperitoneal gas. A dilated loop of small bowel was seen in the left upper quadrant and appeared to contain an ill defined soft-tissue mass (Fig. 2A). An upper gastrointestinal series, performed on the day of admission, revealed a large extrinsic defect on the greater curvature of the stomach. The proximal duodenum was dilated, and no barium passed beyond the ligament of Treitz for a period of two hours (Fig. 2B). The examination was repeated three days later and showed less duodenal obstruction. A large intramural defect was seen in the duodenum near the ligament of Treitz. The lumen in this region was widened, and the mucosal pattern presented a coil spring appearance (Fig. 2, C and D). In view of the similarity of the roentgen findings to those in Case I, a diagnosis of intramural hematoma of the duodenum was made.

Under conservative management improvement was rapid. A gastrointestinal series on July 5 was essentially normal. The patient was discharged on the twentieth hospital day, completely free of symptoms, and remained well during a follow-up period of six months.

**Comment:** Although operative confir-

mation is lacking, the history of trauma, the close similarity of the roentgen appearance to that seen in the other cases, and the spontaneous recovery prompted us to include this case as one of intramural duodenal hematoma.

**CASE III** (reported through the courtesy of Dr. Harry L. Fry): H. M., a 9-year-old boy, was admitted to Bethesda Hospital, Cincinnati, on Dec. 25, 1949, complaining of abdominal pain, nausea, and vomiting of six hours duration.

On admission, the temperature was 99°F., and pulse, respirations, and blood pressure were normal. Except for drowsiness and diffuse abdominal tenderness, physical examination was normal. Hemoglobin was 12 gm., the white blood cell count 18,600, with 91 per cent polymorphonuclear leukocytes, and the urine normal.

A diagnosis of acute appendicitis was made, and the lower abdomen was explored through a right rectus incision. No abnormalities were found. Appendectomy was performed. Postoperatively symptoms persisted, and on Dec. 30 a gastrointestinal series was performed. This revealed narrowing of the descending duodenum and widening of the distal transverse duodenum, where a filling defect was seen. The mucosa in this region showed a coil spring pattern (Fig. 3). A duodenal polyp with intussusception was suspected.

On Jan. 4, 1950, the abdomen was again explored. A bluish cystic mass was found attached to the posterior surface of the transverse duodenum in the retroperitoneal space. The mass was incised



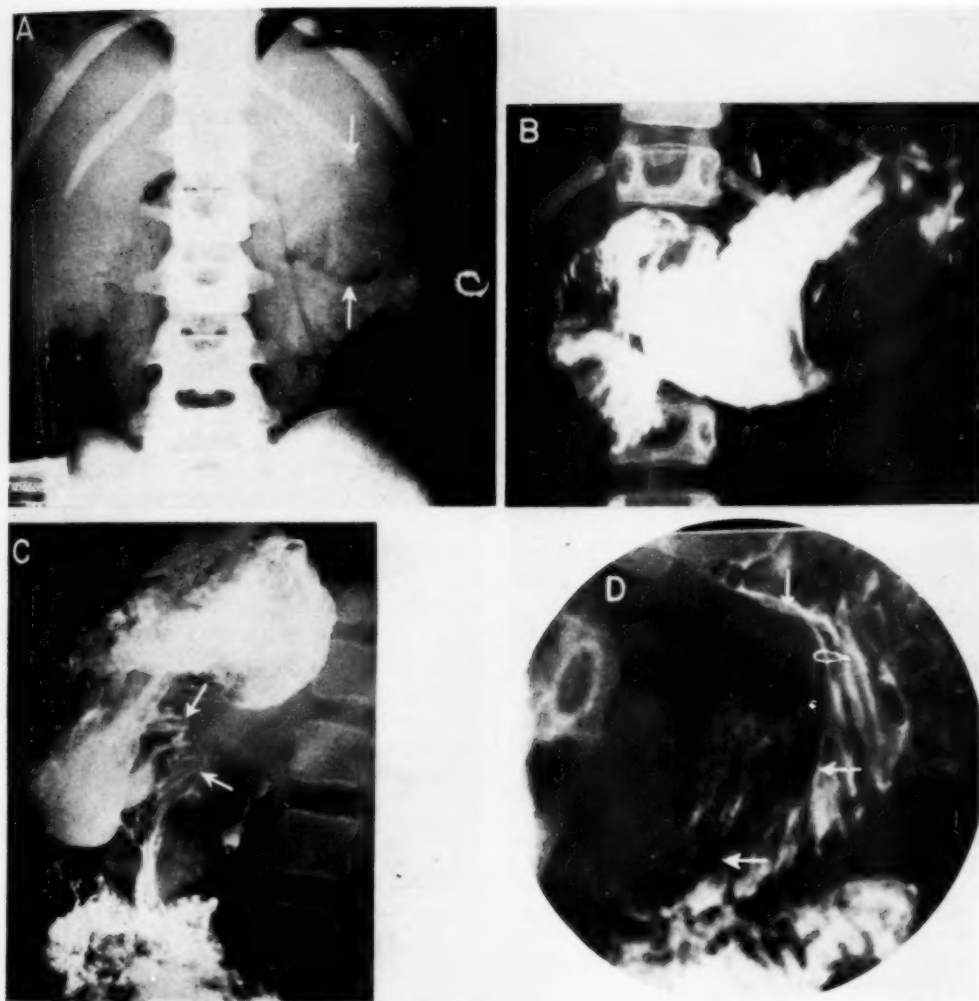


Fig. 2. Case II.

A. Upright film of abdomen on admission (June 22, 1952), showing poor visualization of right psoas shadow, questionable streak of gas density along lateral margin of left psoas shadow, and dilated loop of small intestine containing ill defined mass (arrows).

B. Gastrointestinal series, June 22. Note large extrinsic defect on greater curvature of stomach. No barium entered the jejunum for two hours.

C. Right lateral Bucky film of gastrointestinal series performed on June 25. The distal duodenum is widened and its mucosa presents a coil spring pattern (arrows). There is now less obstruction.

D. Spot film of distal duodenum, June 25, showing the intramural extramucosal lesion (arrows).

through the posterior peritoneum, and about 45 c.c. of old blood clot were removed. Biopsy of the wall of the clot-filled cavity showed granulation tissue.

Upon direct questioning, the child now recalled that one hour before the onset of symptoms he had fallen over a wire and hurt his abdomen. Recovery was uneventful. An upper gastrointestinal series two weeks after operation revealed only a slight area of narrowing in the second portion of the duodenum.

*Comment:* After Cases I and II were encountered, the similar roentgen appearance in Case III was recalled. At the time when the films were originally seen by us, the significance of the roentgen and operative findings was not appreciated.

CASE IV (reported through the courtesy of Dr. Donald D. Brannan, of Cleveland): F. S., a 33-



Fig. 3. Case III. Gastrointestinal series, Dec. 30, 1949. Narrowing of the descending duodenum, widening of the transverse duodenum, and intramural defect with coil spring mucosal pattern (arrows).

year-old male, was hospitalized on Nov. 4, 1951, two days after the onset of severe hiccoughs and vomiting. There was no abdominal pain, hematemesis, or melena, and no history of trauma could be elicited.

Temperature, pulse, respirations, and blood pressure were normal. Physical examination was negative except for muscle guarding over the upper abdomen. Hemoglobin was 15.5 gm., the white blood cell count 16,200, and non-protein nitrogen 98 mg. per cent. The urine showed an occasional granular cast and a trace of albumin.

A gastrointestinal series performed twenty-four hours after admission revealed enlarged mucosal folds and marked eccentric narrowing in the proximal duodenum. No barium entered the distal duodenum (Fig. 4A). A twenty-four-hour film (Fig. 4B) revealed almost complete retention of barium in the stomach and proximal duodenum. The right psoas shadow was obliterated. A large intramural extramucosal mass filled the bulb and descending duodenum and its inferior surface impinged upon the proximal transverse colon.

The patient was transferred to another hospital, where the gastrointestinal series was repeated on Nov. 8. The obstruction now appeared less complete. The intramural defect was seen to extend well into the transverse duodenum, where the lumen appeared considerably widened and a coil spring arrangement of the mucosal folds was apparent (Fig. 4C).

An exploratory operation was performed on Nov. 8, and a large subserosal hematoma was found in the transverse duodenum. It measured 7 cm. in greatest diameter, was ovoid in shape, and extended into the adjacent peritoneum. The hematoma was evacuated and the abdomen closed. Recovery was uneventful.

*Comment:* The hematoma apparently occurred spontaneously in this patient, and no underlying cause could be established. The typical roentgen features of intramural hematoma were present, enabling one of us to make the correct diagnosis at a subsequent film-reading session.

#### DISCUSSION

*Pathogenesis:* Although in 3 of our 4 cases the hematoma was directly attributable to non-penetrating injury, the cases of intramural hematoma of the intestine reported in the literature were frequently unrelated to trauma. Among the latter there was often noted an increased bleeding tendency, usually associated with Henoch's purpura (1) or, rarely, hemophilia (7). In one instance the hematoma was related to a mesenteric cyst (2), and in another to a pancreatic neoplasm (11). Sometimes, as in Case IV, the cause is not apparent. The possibility of unrecognized trauma in such cases must be considered.

In the traumatic cases, the predilection of the lesion for the region of the duodenojejunal juncture is attributed to the fixation of this portion of the gut at the ligament of Treitz. Trauma causes intrusion of the fixed retroperitoneal portion of the duodenum against the spine, and the disruption of the mesenteric attachments in this region probably initiates the hemorrhage (3, 10). Intramural hematoma has also been reported in the colon (6, 8) and in the ileum (1, 5, 7).

At operation a sharply defined hematoma 10 to 20 cm. in length, containing liquid and/or clotted blood, is found in the subserosa of the duodenum. Retroperitoneal hematoma is also commonly present, possibly arising from dissection of the intramural hematoma. In Case I the retroperitoneal and intramural hematomas communicated freely. From the opera-

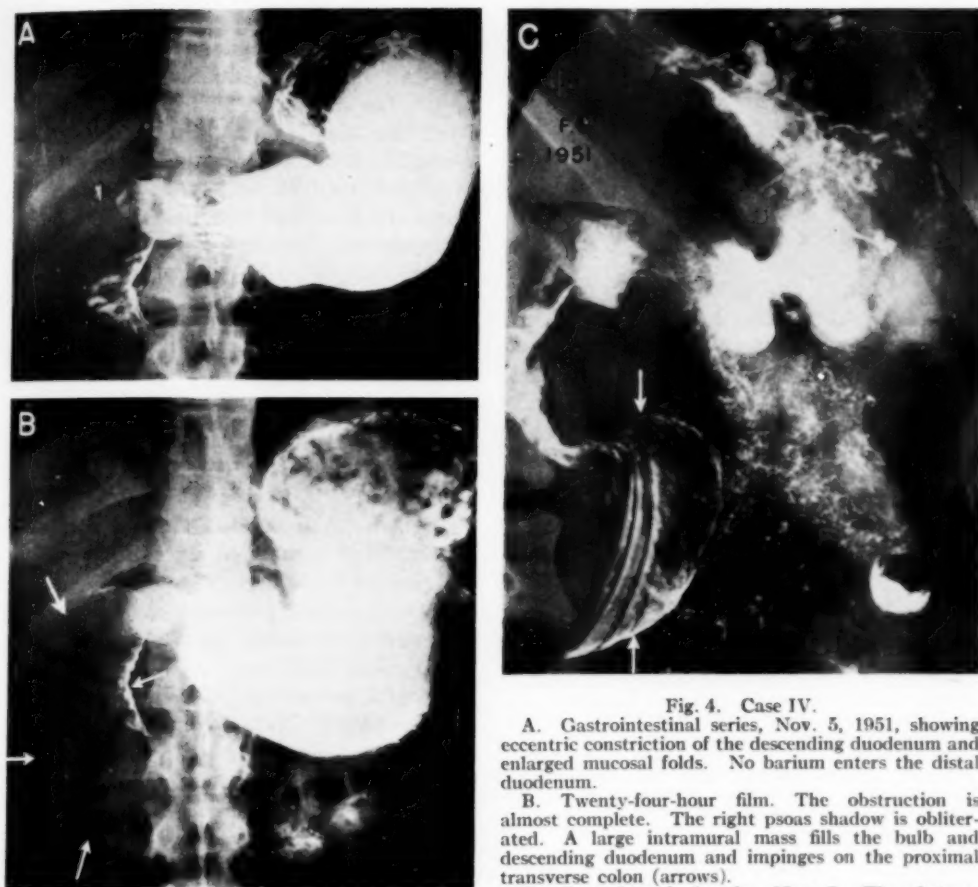


Fig. 4. Case IV.

A. Gastrointestinal series, Nov. 5, 1951, showing eccentric constriction of the descending duodenum and enlarged mucosal folds. No barium enters the distal duodenum.

B. Twenty-four-hour film. The obstruction is almost complete. The right psoas shadow is obliterated. A large intramural mass fills the bulb and descending duodenum and impinges on the proximal transverse colon (arrows).

C. Gastrointestinal series, Nov. 8. The obstruction is now less complete and the intramural defect extends well into the transverse duodenum (between arrows), where the lumen is widened and the coil spring appearance is striking.

tive descriptions in the literature, the lesions occurring elsewhere in the intestine present a similar gross appearance.

We attempted to duplicate the roentgen picture experimentally by utilizing segments of normal small bowel removed intact at autopsy. The segments were filled with a barium suspension and ligated at both ends. Localized injections of up to 150 c.c. of water were made subserosally, intramuscularly, submucosally, or in combination, following which radiographs of the specimens were made (Fig. 5). The coil spring appearance was not reproduced, but an intramural lesion was simulated and the mucosal folds appeared swollen. Attempts to inject more than 150 c.c. of water resulted in extravasation of the water through the cut edge of the mesentery.

Intramural hematoma of the duodenum probably begins in the subserosa, separating the serosa from the muscularis. The resulting tumefaction bulges into the lumen, giving rise to the roentgen signs of an intramural mass. Infiltration of blood or of edema fluid into the mucosa occurs, thickening the valvulae conniventes and producing the enlarged folds seen radiographically. The cause of the coil spring pattern is not clear. As the hematoma enlarges, dissection into the retroperitoneal space may occur.

*Clinical and Laboratory Findings:* There is nothing in the symptomatology, physical

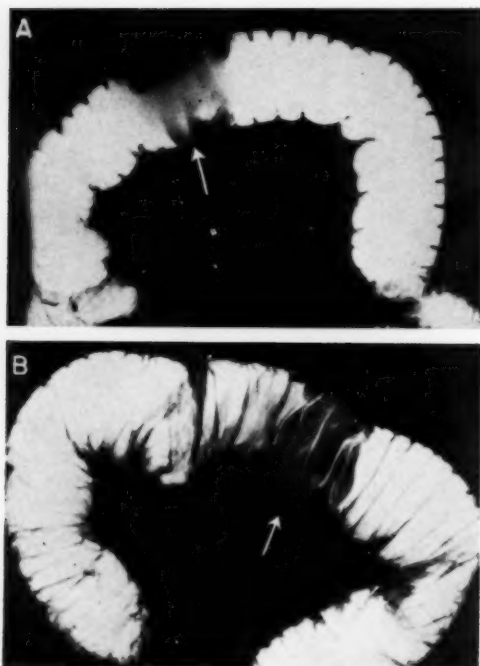


Fig. 5. Experimental attempts to duplicate the roentgen appearance of intramural hematoma. Roentgenograms of barium-filled segments of normal small bowel into which 75 c.c. of water were injected intramurally (arrows). An intramural extramucosal lesion was simulated (A) and the mucosal folds appeared swollen (B), but a coil spring pattern could not be reproduced.

findings, or laboratory data which could be considered diagnostic of intramural hematoma. A history of trauma, however, or of a bleeding tendency may suggest the possibility of this condition. Pain is usually located in the upper abdomen and may be dull, sharp, or colicky. It is often associated with nausea and vomiting, but hematemesis and melena are generally absent. Abdominal examination usually reveals upper abdominal tenderness and muscle guarding. Low-grade fever and moderate elevation of the white count with increase in polymorphonuclear leukocytes are often present. The red count and hemoglobin are usually normal.

**Roentgen Signs:** Plain films of the abdomen were available in only 2 of our 4 cases. In 1, a few distended loops of small intestine were seen in the left upper quadrant.

In the other, an ill defined mass was visible in the lumen of a distended loop of small intestine in the left upper quadrant (Fig. 2A). The right psoas shadow, as seen on the plain films or on the barium studies, was obliterated completely in 2 cases and poorly defined in the other 2. The left psoas shadow appeared normal in 3 cases and was questionably outlined with gas in the other (Fig. 2A).

Gastrointestinal series revealed striking abnormalities, similar in all the cases. The lesions were 10 to 20 cm. in length and involved the descending and transverse portions of the duodenum. In 1 case the bulb was also affected, while in 2 others the hematoma extended for a short distance into the proximal jejunum. In Liverud's case the distal transverse duodenum and proximal jejunum were involved.

The proximal portion of the abnormal segment showed only thickening of the mucosal folds (Fig. 4A). More distally the barium appeared to pass over the surface of a smooth, sharply marginated intramural mass which widened the lumen of the duodenum (Figs. 1B and 2D). In this segment the valvulae conniventes were crowded together producing the coil spring appearance usually ascribed to intussusception (Figs. 3 and 4C). Similar findings were encountered in Liverud's case.

There was evidence of extrinsic pressure on the greater curvature of the stomach in 2 cases (Figs. 1A and 2B) and localized downward compression of the transverse colon in 1 (Fig. 4B). Marked obstruction occurred at the site of the hematoma in 2 patients. In 2 of the 3 cases in which barium studies were repeated preoperatively, the roentgen appearance showed considerable change over a three-day interval (Figs. 2 and 4). A gastrointestinal series was repeated about two weeks postoperatively in 2 patients and two weeks after admission in the unoperated case, and showed marked improvement in each instance.

We believe that the roentgen demonstration of an intramural mass with a coil



spring mucosal pattern overlying it is a pathognomonic sign of intramural hematoma of the duodenum.

**Diagnosis:** The roentgen diagnosis of intramural hematoma of the duodenum should offer no difficulty if a gastrointestinal series is performed and if one is familiar with the entity.

Intramural extramucosal neoplasm is simulated, but the swelling of the mucosa proximal to the main defect, the coil spring appearance, and the length of the abnormal segment make this diagnosis untenable.

The roentgen appearance may resemble that of an intussuscepting mass, but in intussusception oral administration of barium should reveal shortening of the duodenum and visualization of the constricted inner lumen. The rare retrograde intussusception can be ruled out by the eccentric position of the intramural defect, the lack of shortening of the duodenum, and the mucosal changes in the proximal duodenum.

Other conditions, such as pancreatitis, duodenal infarction, and lymphoma or other malignant tumor, should present no serious problem in differential diagnosis if one is familiar with the distinctive roentgen appearance of intramural hematoma.

From the pathological descriptions in the literature, it is probable that similar roentgen changes would also be encountered in intramural hematoma involving other portions of the small intestine. Unfortunately, roentgen descriptions are not available in such cases. In the case of intramural hematoma of the ascending colon reported by Kratzer and Dixon (8) an intramural lesion was suggested by the barium enema study. The reproductions, however, show no evidence of the coil spring appearance.

Intramural hematoma of the duodenum has not heretofore received consideration in the differential diagnosis of the "acute abdomen." If the possibility of this diagnosis is entertained, and if there is no clini-

cal evidence of bowel perforation or other contraindication, a gastrointestinal series should be performed. The demonstration of an intramural extramucosal mass associated with a coil spring mucosal pattern will establish the diagnosis.

#### SUMMARY

1. Intramural hematoma of the duodenum may be traumatic or spontaneous in origin.
2. Its development is associated with acute abdominal symptoms which are non-specific in nature.
3. Gastrointestinal examination reveals a striking roentgen finding which is pathognomonic of this condition.
4. Four cases are reported, in 3 of which surgical confirmation was obtained.

**NOTE:** We are indebted to Drs. Harry L. Fry, of Cincinnati, and Donald D. Brannan, of Cleveland, for permission to report Cases III and IV, respectively.

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(Para el sumario en español, véase la página siguiente)

## SUMARIO

## Hematoma Intramural del Duodeno

El hematoma intramural del intestino es un estado en el que, ya espontáneamente o a consecuencia del traumatismo, extravasa una aglomeración localizada de sangre a los tejidos subserosos o intersticiales del intestino. Preséntanse 4 casos, en los que estaba afectado predominantemente el duodeno.

Los hallazgos físicos, semiología y datos de laboratorio no son específicos, pero una historia de traumatismo o de diátesis hemorrágica pueden indicar la posible existencia de la lesión. En todos los casos de los AA., se evidenció una notable obser-

vacación roentgenológica, que ha sido mencionada también por Liverud. El bario parecía pasar sobre la superficie de una tumefacción intramural, netamente demarcada y lisa, que dilataba la luz del duodeno. En ese segmento, las válvulas conniventes estaban apiñadas, teniendo aspecto de muelle enrollado, lo que parece ser patognomónico del estado. Aunque el cuadro roentgenológico puede semejar el de la invaginación, debe excluirse el último por la falta de acortamiento del duodeno y de encogimiento del interior de la luz.

## DISCUSSION

**Richard Schatzki, M.D.** (Belmont, Mass.): The description of Drs. Felson and Levin of the roentgen appearance of these intramural hematomas adds another facet to our knowledge of the pathology of the gastrointestinal tract, and we are greatly indebted to Dr. Felson and his associate for bringing it to our attention.

I personally have never seen such a hematoma in the duodenum. One of the reasons for it is that I have not performed gastrointestinal examinations shortly following an abdominal injury.

The appearance of the lesion seems to be characteristic and easy to recognize if one is familiar with it. Dr. Felson's differential diagnosis against intussusception and intramural lesions other than hematoma is convincing in the cases which he presented. I think it is always a little dangerous to call a sign diagnostic or pathognomonic, and I am wondering if it isn't possible that smaller areas of hematoma might not produce a picture which simulates an intramural tumor more closely. Certainly the cases which were shown looked in many respects different from intramural tumor.

As far as the coiled spring appearance and its origin is concerned, it came to my mind as I listened to Dr. Felson that the two characteristic lesions which produce this picture are intussusception and intramural hematoma, in each of which the distention of the small bowel occurs very rapidly. The rapidity of this distention may have something to do with the formation of those coils.

The absence or poor demonstration of the psoas shadow—in Dr. Felson's cases always on the right side—is of great interest. It probably will play an important role in arousing suspicion of a hemorrhage in the wall of the duodenum in future cases, even before a gastrointestinal series is performed.

When should we undertake a gastrointestinal

examination after abdominal trauma and what should be done if intramural hematoma is found? I personally would still greatly hesitate to attempt such an examination shortly after trauma, but with the knowledge which I have obtained here this morning I certainly will in the future perform one in those not uncommon cases where the clinical picture is not dramatic enough to demand surgery but where some abdominal symptoms linger on in the days following the injury. The demonstration of an intramural hematoma in such a case localizes the abdominal injury and therefore is of clinical significance.

What should be done if the hematoma is demonstrated? Two of Dr. Felson's cases—one which was and one which was not operated on—showed rapid regression of the duodenal defect. The intramural blood either became rapidly absorbed or, more likely, emptied itself into the retroperitoneal space. One wonders whether this might not be the usual course of events and whether surgery is necessary in these cases, provided that the clinical course is mild and does not indicate additional bowel injury or recurrent hemorrhage.

I wish to thank Drs. Felson and Levin for this new piece of equipment in our diagnostic tool kit.

**Dr. Felson (closing):** We so far feel that the sign is pathognomonic of intramural hematoma of the duodenum. We have never seen it in other conditions, and the only reference to it is in the article by Liverud.

The question of performing a gastrointestinal series on a patient following an acute abdominal episode came up in our minds as well. These patients did not seem to be ill enough to have a perforation of the gut, although of course that was a possibility. They were not, as a rule, surgical emer-

gencies and the surgeon did not plan to operate immediately; else we would not have had the opportunity of doing a gastrointestinal series. In fact, we relied entirely on the judgment of the surgeon in this respect.

As to the management after the diagnosis is made, we cannot say from our experience with the one case treated conservatively whether non-operative management is the method of choice. I don't think we should generalize on this case, since we

known that concomitant lesions may occur following trauma, and the roentgen examination might demonstrate only the hematoma and fail to reveal other conditions for which surgery might obviously be indicated.

I think the surgeon could detect clinically the manifestations of those conditions which would require surgery, but I am not certain of this. Therefore, we cannot yet conclude that these patients should be treated conservatively.



## Volvulus of the Transverse Colon<sup>1</sup>

LEO S. FIGIEL, M.D., and STEVEN J. FIGIEL, M.D.

**V**OLVULUS OF THE transverse colon constitutes one of the rarest forms of mechanical obstruction of the large bowel, and reliable radiologic documentation of such an accident occurring in a normally developed colon (excluding anomalies of rotation) is indeed unusual. Kallio (10), in 1932, collected 18 cases, including 2 from his own experience, and stated that, although uncommon, volvulus of this type was possible in the presence of an extremely redundant transverse colon whose flexures were in unusually close proximity; the torsion mechanism thus was similar to that occurring in the sigmoid. Kallio furnished an excellent review of the literature and the reader is referred to his paper for references to the earlier cases. The only subsequent contributions dealing with this condition are single case reports by Groth (8) in 1934, Melchior (13) in 1934, Martin and Ward (12) in 1944, Tabanelli (18) in 1947, Olivier and Libaude (15) in 1948, Murray (14) in 1950, and a report of 2 cases by Buenger (3) in 1954.

Upon analysis of the descriptive and illustrative material in the papers of Melchior and Murray it is readily apparent that anomalies of rotation existed in their cases prior to the development of volvulus. Copies of roentgenograms submitted by Tabanelli strongly contradict the surgical impression of volvulus, since a barium enema study demonstrated filling of the transverse colon, including both flexures, without revealing unusual redundancy or obstruction. Possibly a redundant loop-like right colonic segment was twisted at its base, as has been reported by Homans (9). Even this possibility cannot be accurately established from the radiographs shown.

The cases of Groth, of Martin and Ward, and of Olivier and Libaude, appear

to constitute duly authenticated examples of volvulus of the transverse colon. In the case of Groth, the diagnosis of axial torsion was established by preliminary barium enema examination demonstrating a funnel-shaped obstruction in the proximal half of the transverse colon just to the right of the mid-line, with a detailed study showing spiraling and crossing of mucosal folds at that site. This obstruction was overcome with some difficulty, with barium filling the proximal colon. The torsion was apparently reduced during expulsion of the enema and recurred a few days later. Groth considers this to be a physiological type of torsion, which on occasions may be associated with obstructive symptoms.

The case of Olivier and Libaude showed a rounded termination of the barium column, with a dentate margin, at the site of obstruction in the distal transverse colon and a severely distended, redundant transverse colon proximally. At surgery a torsion of 180° was present. Although the diagnosis of volvulus was not established prior to operation, it would appear that the combination of a sharply rounded termination of the injected barium at the site of obstruction, plus the severe redundancy and distention, should have suggested the diagnosis. Our experience (5) with volvulus of the right colon indicates that a rounded termination of the barium column at the site of torsion is not uncommon. In the case to be presented here, the pre-evacuation barium enema study demonstrated a rounded termination with a central dentate margin at the obstructive site; only on the post-expulsion study was there evidence of spiraling and crossing of mucosal folds, indicating conclusively the presence of torsion.

Martin and Ward described a case of

<sup>1</sup> Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill. Dec. 13-18, 1953.



megacolon apparently due to an inflammatory stricture in the descending colon complicated by volvulus of the transverse colon, the surgical report indicating a complete twist at the base of a very redundant transverse colonic loop. The film studies illustrating their paper are not such as to establish the diagnosis of volvulus, nor does the case history indicate that the diagnosis was made preoperatively.

Recently Buenger published a report describing 2 cases of volvulus at the splenic flexure of the colon. The inference of torsion occurring at this site is somewhat misleading, since the splenic flexure ordinarily constitutes one of the relatively constant fixed points of the colon. The radiographic and clinical evidence presented is not very convincing of a torsion accident as one ordinarily thinks of it, where abnormal mobility constitutes a prerequisite, but certainly, in the first case at least, is consistent with abnormal rotation and fixation of the distal transverse colon secondary to multiple adhesions and bands, as described in the accompanying surgical report.

Riedel (16), in 1894, made reference to rotation of the transverse colon secondary to inflammatory bands and adhesions and described 2 such cases. Finsterer (6) also reported the presence of an inflammatory band in a case of volvulus of the transverse colon.

Finsterer stressed the possibility of double obstructions in cases of volvulus of the transverse colon and stated that organic lesions in the distal colon should always be excluded when torsion of the transverse colon is found. He described a case in which a co-existing carcinoma of the sigmoid was present. The cases of Roos and Curschmann (quoted by Kallio), in which coexistent volvulus of the sigmoid and transverse colon was present, tend to support Finsterer's contention. In a recent personal communication, Becker (1) described an instance of volvulus of the transverse colon operated upon at the Charity Hospital in New Orleans in a patient who previously had a resection

of the sigmoid because of volvulus. No films of this case are available. The case of Martin and Ward, in which a megacolon apparently due to an inflammatory stricture of the descending colon was complicated by volvulus of the transverse colon, is also of interest in this connection.

In view of the widespread usage of radiography in the study of intestinal obstruction, this scarcity of reference material must be considered significant, especially since marked redundancies of the transverse colon are extremely common. We recently had the experience of studying a case presenting clinically and radiographically the features of intestinal obstruction. We were extremely surprised to demonstrate torsion effects on the mucosa of the mid transverse colon, with complete obstruction apparently due to volvulus, and even more surprised when at surgery it was discovered that the proximal half of the transverse colon had herniated through a tear in the mesocolon, with a complicating volvulus of 360°. From this it would appear that hernias, internal or external, in which the transverse colon participates, may be complicated by torsion.

#### CASE REPORT<sup>2</sup>

F. P., a 56-year-old white female, was admitted on Oct. 15, 1951, with abdominal pain, distention, and vomiting. In November 1950, she had been admitted to another hospital for intestinal obstruction, and a cecostomy had been performed. Scout films of the abdomen at that time revealed a complete obstruction at the mid transverse colon with severe distention of the right colon and proximal half of the transverse colon. No cause for this obstruction was ascertained at operation.

*Roentgen Examination:* Anteroposterior and upright studies (Oct. 15, 1951) revealed severe right colonic distention and moderate distention of the proximal transverse colon, which assumed a "U"-like appearance, with the apex of the "U" directed inferiorly. A barium enema study revealed a complete obstruction at the mid transverse colon and films demonstrated spiraling or twisting of the mucosa at the site of obstruction. *Impression:* Volvulus of the transverse colon with complete obstruction.

<sup>2</sup> This case is submitted through the courtesy of J. E. Lofstrom, M.D., Director of Division of Radiology, Wayne University and Receiving Hospital, Detroit, Mich.



Fig. 1. Gas-distended, redundant proximal transverse colonic segment with conization of the gas column at the proximal and distal aspects of this redundant loop. Note also distention of the right colon.

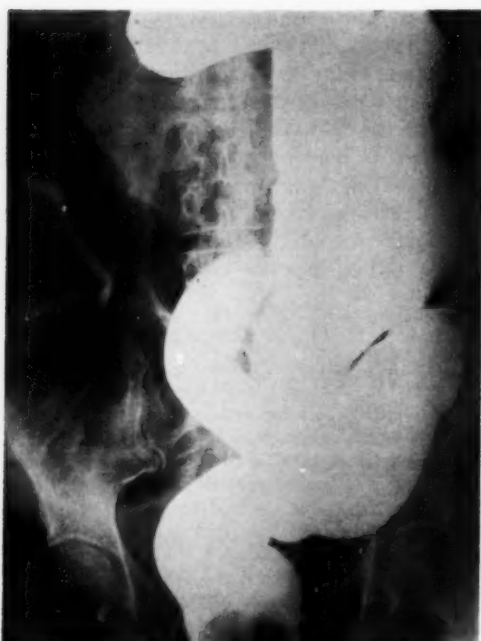


Fig. 2. Rounded termination of barium column at the point of obstruction, with central dentate margin.

*Course:* Because of inflammatory signs at the old cecostomy site, surgery was deferred while the patient was treated intensively with antibiotics. The cecostomy opened spontaneously, with drainage of considerable gas and fluid.

*Surgery:* Exploration, on Oct. 24, revealed evidence of multiple adhesions and a tear in the transverse mesocolon through which the proximal half of the transverse colon had herniated, with a result-



Fig. 3. Post-evacuation study showing crossing and spiraling of the mucosal folds at the point of torsion, conclusively indicating the presence of volvulus.

ant torsion of  $360^\circ$ . The herniation of the colon was reduced, the tear repaired, and a cecostomy was done. A right paraduodenal hernia was also reduced during the surgical procedure.

#### COMMENT

This case illustrates an extremely rare type of mechanical obstruction, consisting of herniation of the proximal half of the transverse colon through a tear in the mesocolon, complicated by volvulus. Pathognomonic evidence of torsion is demonstrated on the barium enema studies. The defect in the mesocolon was probably an acquired one, related to previous surgery. No explanation was offered by the surgeons to account for the obstructive process which occurred in November 1950. The only pertinent comment in the operative notes was that the right colon was extremely mobile.

We believe that the term "volvulus of the transverse colon" should be rigidly and specifically applied to those cases in which torsion is demonstrated in the transverse colon and in which anomalies of rotation (non-rotation, malrotation,

reversed rotation) are not present. If such anomalies of rotation are excluded as an underlying anatomical defect, volvulus of the transverse colon becomes one of the rarest forms of intestinal obstruction.

#### SUMMARY

1. A case of volvulus of the transverse colon occurring as a result of herniation through a tear in the transverse mesocolon is presented.

2. A review of the literature is included and the rarity of volvulus of the transverse colon in the normally developed colon (excluding anomalies of rotation) is stressed.

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#### SUMARIO

#### Vólvulo del Colon Transverso

El vólvulo del colon transverso es una de las formas más extrañas de oclusión mecánica del intestino grueso, a pesar de ser sumamente común la sobreabundancia de tejido en dicha región. Repásase la literatura y preséntase un caso. Descubriéronse en las radiografías corrientes acentuada distensión de la porción derecha del colon y moderada distensión de la porción proximal del colon transverso y un estudio

con enema de bario reveló oclusión total del colon mesotransverso y torsión de la mucosa en el sitio de la obstrucción. La operación reveló un desgarró (presuntamente relacionado con una operación anterior) en el colon transverso, a través del cual se había herniado la mitad proximal del último, dando por resultado una torsión de 360°. Se redujó la hernia y se reparó el desgarró.

#### DISCUSSION

John Holt, M.D. (Ann Arbor, Mich.): It is difficult not to be over-enthusiastic about the paper we have heard on volvulus of the colon. Considering the recently published article by these same authors on volvulus of the cecum and ascending colon, their very fine exhibit at this meeting, and this presentation this morning, it is

hard to find something to say that they haven't already said.

A couple of weeks ago, flush with confidence in making this diagnosis after reading the copy of the paper which was sent to me, I was confronted by a scout film of the abdomen which one of our surgeons thrust in front of me and I immediately

made a dogmatic, unequivocal statement that this was volvulus of the sigmoid colon. All the basic criteria for such a diagnosis seemed to be present in this fifty-year-old woman who had had a previous episode of volvulus of the sigmoid colon in 1951 and who had not had an obvious redundancy of the sigmoid loop resected at the time of operative correction of the volvulus.

Imagine my surprise when the surgeon informed me that, although he found a dilated sigmoid loop, there was no twist. It was, in his opinion, an example of megacolon largely confined to the sigmoid area.

I still am somewhat skeptical about the surgical diagnosis and would like to ask Dr. Figiel if he has had any experience with chronic or recurrent volvulus and if this case might be an example of the same. Furthermore, might not volvulus of this type be responsible for some of the examples of so-called localized acquired megacolon in adults? Finally, how much of a twist does it require to produce obstruction? The reason I ask this is because a review of this patient's previous record discloses that the surgeon who made the diagnosis of the first occurrence of volvulus said there was apparently only a 90° twist.

I again want to thank Drs. Figiel for an interesting and instructive presentation. I am sure that their work during the past several years will serve as important references for all of us in the future and that we will make more diagnoses of volvulus of the colon because of their contributions.

**Dr. Leo Figiel (closing):** Dr. Holt's first question was as to whether we felt that in his case a recurrent chronic volvulus was associated with the megacolon. I feel definitely that Dr. Holt's description indicates the presence of a sigmoid megacolon rather than a generalized form, that is, Hirschsprung's disease, although in the latter condition cases of sigmoid volvulus have also been reported. There is very convincing evidence that a definite anatomic change may occur in the sigmoid loop, primarily in association with high-residue, bulky diets such as are common particularly among the Scandinavian and Russian people. The sigmoid becomes quite huge and subject to recurrent attacks of torsion which may be spontaneously reduced.

In our own country, sigmoid volvulus occurs in institutions, in homes for the aged where there is poor bowel care, etc. In any event, volvulus anywhere in the colon can be spontaneously reduced, and a number of cases are described in which detorsion of volvulus in varying segments was demonstrated. It is of interest that most patients treated for obstruction of the colon due to volvulus will present histories indicating that such attacks have occurred many times previously.

As to Dr. Holt's second question—how much of a twist is necessary to produce torsion?—I would say that probably 80° is necessary. I doubt very much if torsion less than that will produce roentgenographic evidence of mechanical obstruction, although there may be some symptomatology associated with such minor displacements.

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## The Significance of Variations in

## Angiocardiographic Circulation Times<sup>1</sup>

MELVIN M. FIGLEY, M.D.

AS A MEANS OF demonstrating the morphology of the heart and great vessels, angiocardiography has proved to be practical and valuable. When rapid serial filming is used, the recording of sequential opacification and clearing of the several cardiac chambers and vessels presents an opportunity to study circulatory physiology as well. It seemed of interest and value to correlate the pressures and evidences of shunts obtained at cardiac catheterization with chamber filling and emptying times as shown by short-interval angiocardiography.

### METHODS

At the University of Michigan Hospital angiocardiography has been performed with automatic serial filming (1) at the rates of 1.3, 2, and rarely 4 films a second. Tests of the electronic timer employed have shown remarkable uniformity of exposures at these filming rates. The time of appearance and disappearance of contrast in the individual heart chambers and vessels has been recorded for a number of normal and congenitally abnormal hearts. A single observer's visual estimate of the earliest and latest definite opacification was recorded. Films were viewed in large groups, facilitating the recognition of slight changes in density, the influence of respiration, Valsalva effort, hepatic reflux, etc.

Certain difficulties were encountered. The initial opacification of a chamber is ordinarily sufficiently abrupt to be easily recognized, but the clearing time, particularly in disease, is often indefinite. At times an overall slight opacity of the right heart remains after the bulk of the contrast medium has passed. In such a case

the termination of changing density was used. In some instances filming was not continued long enough to record complete left heart clearing. Superimposition of chambers in certain projections prevents separate recording, *i.e.*, the right auricle and ventricle are superimposed in the left oblique view.

Consideration was given to the desirability of densitometric rather than visual measurements (2). With the former, a curve of changing density could be constructed. Previous experience, however, indicated that this would be time-consuming and difficult on account of the non-uniform density and position of the chambers. Also the light transmission of the heavily contrast-filled right heart chambers might be so great as to prevent accurate measurement by the available densitometer.

The details of angiocardiographic technique are important as sources of deviation from the commonly studied physiologic states. In this hospital premedication consists of morphine or a barbiturate. General anesthesia is not required, nor is any other drug used. Children up to the age of six or seven are examined recumbent, with no attempt to control respiration. Ordinarily they are quiet at the outset but with the injection may give an apprehensive inspiratory gasp and hold the breath or cough or cry during the latter part of the filming. In others, who tolerate it placidly, the examination disturbs the resting physiologic state only by infrequent direct effects of the contrast medium on the heart (11).

Older children and adults are examined in a sitting position. Despite sedation and reassurance, there is sometimes a threat of

<sup>1</sup> From the Department of Radiology, University Hospital, University of Michigan, Ann Arbor, Mich. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13-18, 1953.

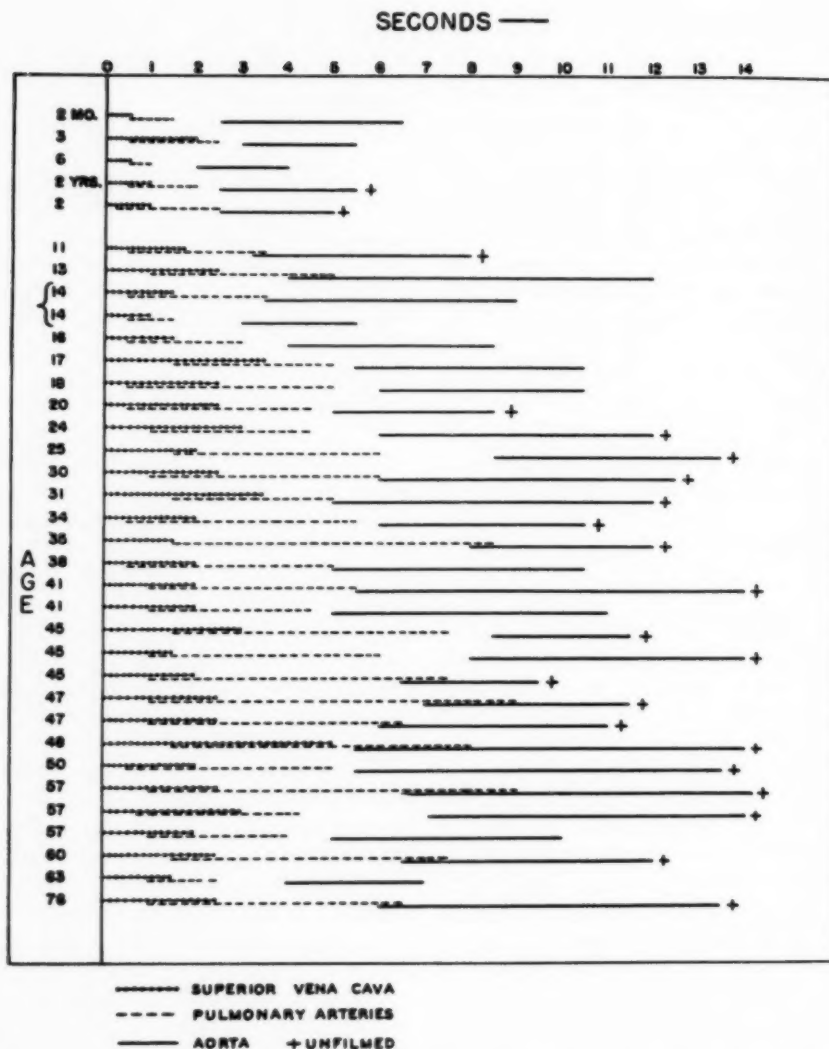


Fig. 1. The normal opacification periods of the superior vena cava, pulmonary artery and its main branches, and the aorta. Timing begins with the initial entry of the contrast medium into the intrathoracic veins. Note that with few exceptions there is no overlapping opacity of the pulmonary arteries and the aorta.

syncope during preliminary preparations. All those so affected have successfully undergone examination after brief recumbency and inhalation of spirits of ammonia. Ordinarily injection is begun with the initiation of a deep but not maximal inspiration, and the breath is held for twelve to fifteen seconds, during the entire filming cycle. Should longer filming be planned, one expiration and inspiration

are allowed at five to eight seconds. Clearly there is opportunity for the Valsalva effort to delay the entrance of the contrast medium or to cause serious impairment of venous return during filming. Performed in this way, the examination is not one of a comfortable physiologic state. It is, however, the technic most widely employed because of its simplicity.

Injection is made manually as rapidly as

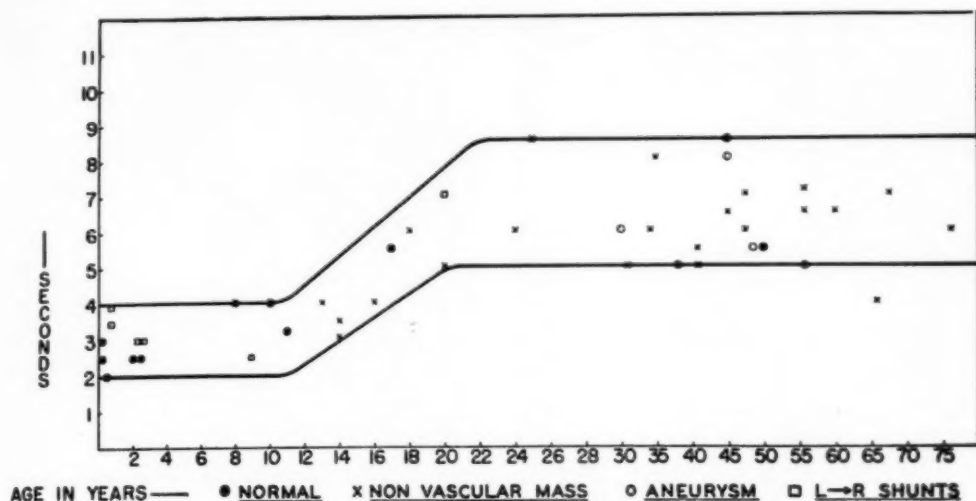


Fig. 2. The normal range of initial aortic opacification times plotted against age. The cases designated as *normal*, *non-vascular mass*, and *aneurysm* are the same as those charted in Fig. 1. None of these patients showed convincing evidence of heart disease. Those designated as *L → R* shunt had some type of intrathoracic arteriovenous shunt not complicated by congestive heart failure. The heavy lines in this and the following charts indicate the extremes of the normal range.

possible through a large cannula inserted in an antecubital or saphenous vein. Dosage of the medium—formerly Diodrast or Neo-Iopax, and now Urokon 70 per cent—is 1 c.c. for 2 pounds of body weight, irrespective of heart size, up to a maximum of 50 c.c. Dotter (3) and Sussman (11) have reported no change in right auricular pressure in adults during injection, but we, like others (4), firmly believe that this pressure is briefly elevated in infants. We have not taken opportunity to determine this, however.

#### OBSERVATIONS

**Normal Circulation:** The normal circulation is distinguished by rapid clearing of the right heart, which results in a convenient constant, namely, complete clearance of the main pulmonary arteries by the time of initial opacity of the ascending aorta. This constant is observed if the injection time, as measured by the duration of superior vena caval opacity, is as rapid as one-half to one second in infants and two to two and one-half seconds in adults. The lack of overlapping of pulmonary artery and aortic opacification in most normal hearts may be seen graphi-

cally (Fig. 1). The bulk of patients included here were studied for intrathoracic masses and had no clinical evidence of cardiac disease or compression by the mass. Several others had aneurysms or anomalous aortic branches.

From the data available, the normal range of filling and emptying times of each of the several chambers has been determined, but for convenience a single value expressing the speed of the right heart circulation was desired. For this, initial opacification of the ascending aorta was chosen as it is ordinarily abrupt and easily recognized in any projection. As it may be affected by disease of any of the chambers, valves, or vessels proximal to it, it should be a sensitive indicator of the condition of the intrathoracic circulation.

A plot (Fig. 2) of the initial aortic opacification time after the first entry of contrast medium into the chest shows a fairly sharply defined normal range, the time increasing up to the mid or late teens. The decrease in heart rate with advancing age is almost certainly responsible for this. It seems probable that the circulation rate might be expressed more precisely and

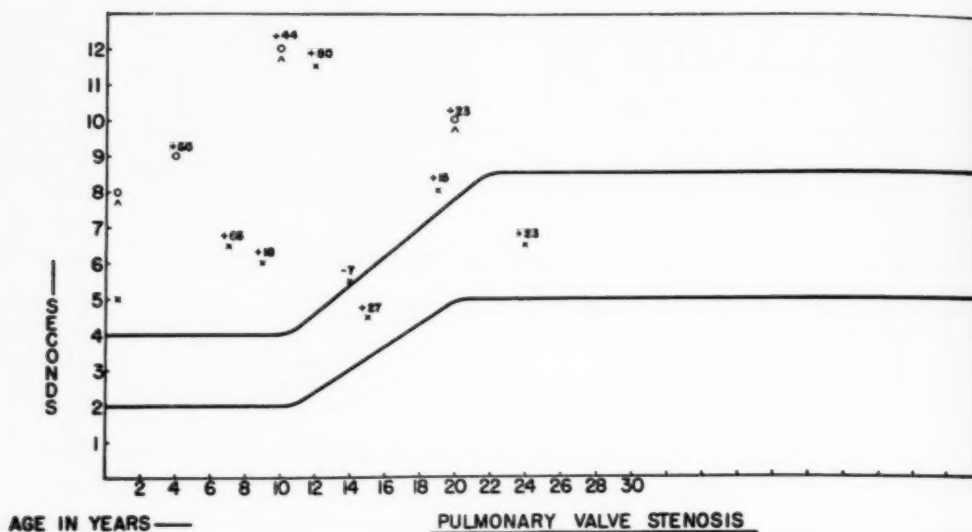


Fig. 3. Pulmonary valve stenosis with intact ventricular septum. Initial aortic opacification *via* pulmonary flow (X) or pulmonary artery clearing (O) when aortic filling time exceeded the filming period plotted against age. Subscript  $\Delta$  indicates a value greater than recorded because the filming period was exceeded. Figures indicate per cent deviation from predicted normal frontal area of the heart. Note the generally slow circulation correlating roughly with increased heart size.

meaningfully in the number of cycles required for initial aortic opacification. In a few instances we have obtained simultaneous electrocardiograms and found that the adult heart requires seven to eight cycles for this event. In very beautiful biplane studies of infants, Wegelius and Lind (4) have found left heart filling normally limited to eight to twelve cardiac cycles after right auricular filling. They advise expressing opacification times independent of the heart rate in terms of cardiac cycles for a given event.

**Left - to - Right Shunts:** Left - to - right shunts, as in uncomplicated patent ductus, auricular or ventricular septal defects, or anomalously connected pulmonary veins, are distinguished by a normal initial aortic opacification time associated with prolonged pulmonary artery opacification. The latter fades very gradually with left heart clearing, which is also prolonged due to the recirculation.

Ideally one might expect clear-cut emptying of the right heart and demonstrable refilling by the anomalous shunts, which might then be distinguished. Actually

this seldom occurs. Three of 8 surgically verified patent ducti showed clear-cut pulmonary recirculation from the aorta after the right ventricle had cleared. Two of 4 auricular septal defects showed convincing right auricular reopacification. Each of 2 ventricular septal defects had demonstrable refilling of pulmonary arteries simulating patent ductus. In all cases prolonged pulmonary artery opacification was noted, which gradually cleared with aortic clearing.

The numbers of patients studied with these shunts are small, for angiocardiology adds little or nothing to the much more precise differentiation afforded by clinical examination and cardiac catheterization. In this hospital only an occasional atypical case is studied by angiocardiology.

**Pulmonic Stenosis:** Pulmonary stenosis and pulmonary hypertension present obstruction to right ventricular emptying with resultant ventricular hypertrophy and dilatation. Retarded clearing of the contrast medium from the right ventricle and delayed aortic opacification may be



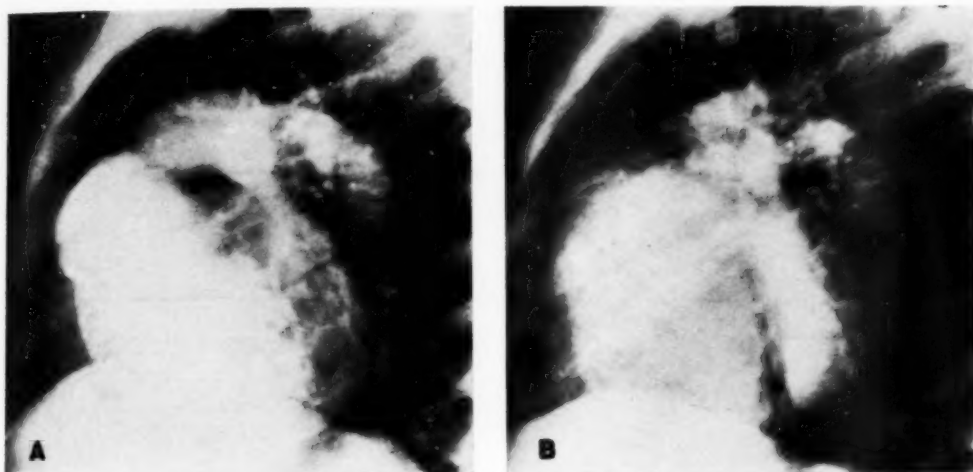


Fig. 4. Delayed right ventricular clearing in pulmonary valve stenosis. Lateral angiocardigram, 2 films per second; Female, aged seven years. A. At 3.5 seconds, enormously dilated right ventricle and constriction at valve ring (arrow). The stenotic valve is not visible. B. At 7.5 seconds, delayed clearing of the right ventricle, diminutive left ventricle and ventricular septum (arrow). Normal right ventricular clearing time is not over four seconds at this age.

expected and are in fact found in many instances.

Pulmonary stenosis may be encountered as a simple narrowing of the valve orifice through which all blood must flow or in association with a ventricular septal defect, as in the tetralogy of Fallot. For 12 patients of the former type we obtained angiocardio-graphic data. In 8 of these the pulmonary circulation was significantly slowed, as shown in Figure 3. The aortic opacity here recorded is not that due to an early right-to-left auricular shunt, which was present in several of these patients, but that obtained by the normal pulmonary route. Among the 9 cases in which the observation could be made, right ventricular or pulmonary artery clearing was delayed in 5 (Fig. 4). This might be ascribed to an abnormally large diastolic chamber volume relative to the stroke volume. Some support for this view is presented by the fact that the smaller hearts had the more nearly normal circulation times.

The severity of the stenosis in these patients can be judged only by evaluation of symptoms, heart size, and right ventricular pressure. The relative reduction in

pulmonary flow was not determined. In general, the less severely handicapped had the more nearly normal circulation. The 3 patients with entirely normal circulation times were only mildly incapacitated.

Of about 50 patients with tetralogy of Fallot, a few had sufficient pulmonary flow to allow useful opacification of the left heart. In general, these were the less severely affected patients; in the more severe cases, most of the medium enters the aorta immediately, the amount traversing the lungs being inadequate for left heart opacification. In general (Fig. 5), there is some slowing of flow through the lungs, though not as marked as in valvular stenosis with intact ventricular septum. By contrast, right ventricular emptying is consistently prompt, apparently because of the direct access of the ventricle to the aorta.

*Pulmonary Hypertension:* The patients selected for study of pulmonary hypertension were those in whom this condition complicated a ventricular or auricular septal defect or a patent ductus. Two cases of isolated pulmonary vascular disease were included. Mitral valve disease, though commonly accompanied by pul-

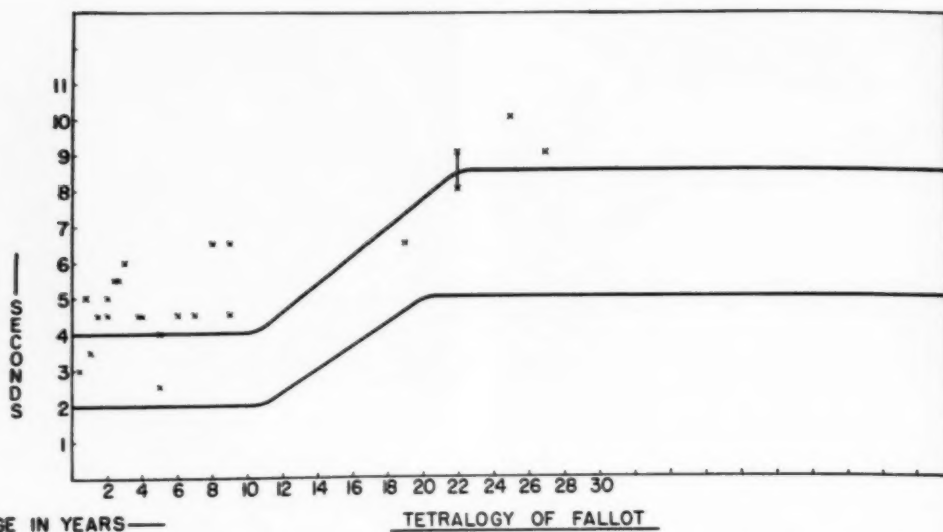


Fig. 5. Tetralogy of Fallot: initial aortic opacification *via* pulmonary flow. Premature opacification of the aorta due to intracardiac right-to-left shunting has preceded this second aortic opacification cycle. Note a general delay in pulmonary circulation, though less marked than in Fig. 3. Two values joined by a line represent two examinations of the same patient.

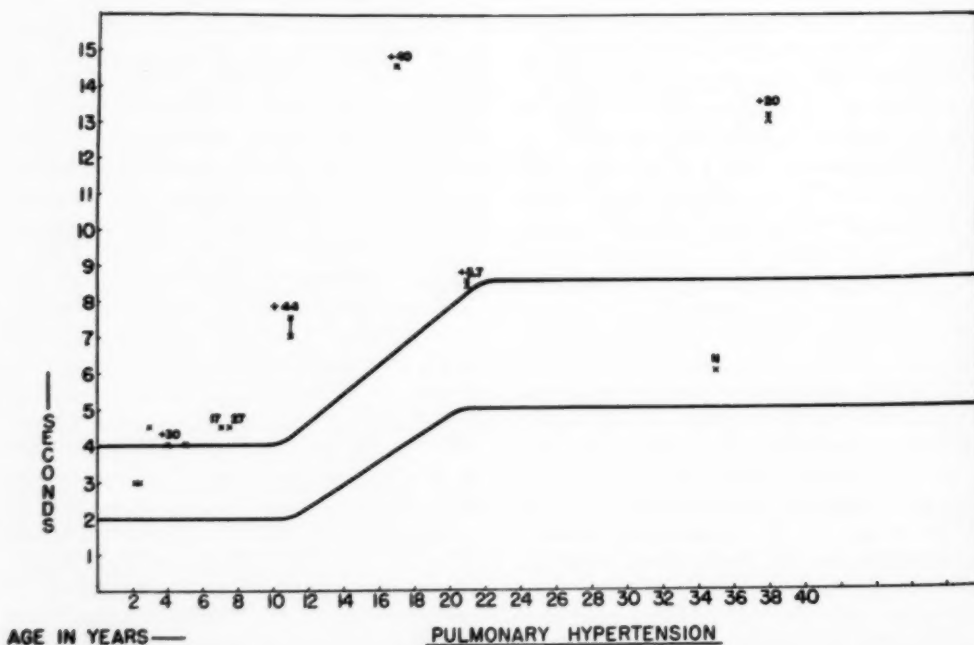


Fig. 6. Pulmonary hypertension: initial aortic opacification *via* pulmonary flow. Right ventricular systolic pressure 100 mm. Hg or more in 8 patients, 55 to 68 mm. in others. Except for patient aged seventeen, none had experienced heart failure. Other figures and symbols as in earlier Figures. Note a general tendency for delayed aortic opacification, *i.e.*, slow pulmonary circulation.

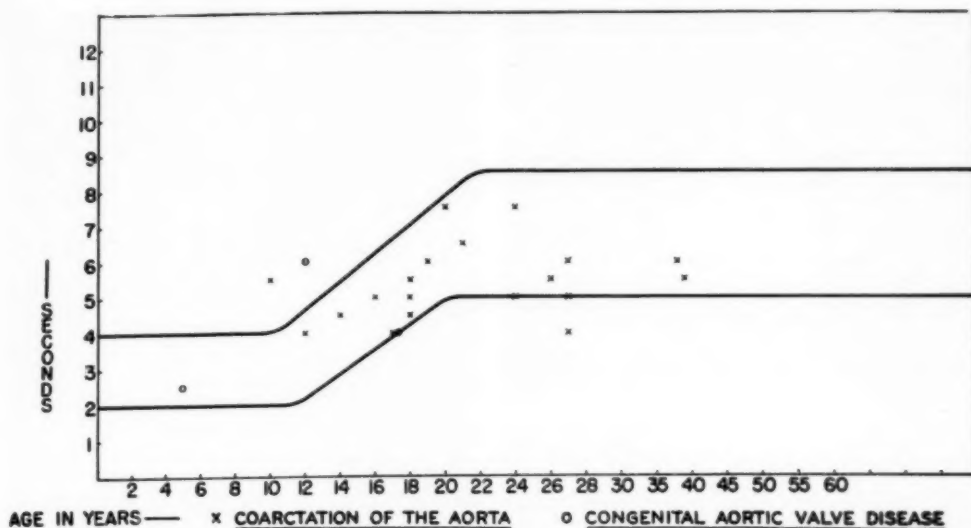


Fig. 7. Coarctation of aorta and congenital aortic valve disease: initial aortic opacification. Normally rapid circulation is recorded despite left-sided obstruction.

monary hypertension, may in itself be obstructive and was not included.

Only 3 of these 12 cases were well above normal in their aortic opacification (Fig. 6). In 5 of 11 cases where it could be evaluated, right ventricular emptying was delayed. There was no correlation with the level of pulmonary pressure, which in most instances was about 100 mm. Hg systolic. The relation of heart size was also inconstant.

Several cases each of mitral valve disease, constrictive pericarditis, and congestive heart failure of unknown cause were studied, each showing greatly retarded circulation. Pulmonary hypertension was demonstrated in all of these, but the other complex factors involved render any conclusions regarding the role of the pulmonary pressure mere speculation.

*Coarctation of the Aorta:* As a matter of interest, the circulation time in coarctation of the aorta was studied to see if an obstructive lesion of the left heart had any effect on the right heart circulation when congestive failure was not present. Some of these patients had left ventricular enlargement, about 40 per cent, but none

were in failure. The expected normalcy of the circulation rate was confirmed (Fig. 7). Likewise, 3 patients with congenital aortic valve disease showed no deviations from normal.

#### DISCUSSION

It is at once apparent that standard angiocardigraphic technic as a method of assessing intrathoracic circulation times is far from ideal. Its defects lie in the injection, the filming, and the lack of heart rate control.

In 1943 Steinberg and others (5), in one of the first papers concerning the application of angiocardigraphy to congenital intracardiac shunts, pointed out that injection is subject to effects of the Valsalva effort and hepatic reflux. Each results in intermittent or delayed entry of the contrast substance. These may not affect the speed of passage, recorded as the initial aortic opacification time, but they invalidate observations based on right heart-clearing times.

The Valsalva effect is shown in Figure 8. It is pertinent to point out the frequency of hepatic reflux. This very commonly occurs to a limited extent during the

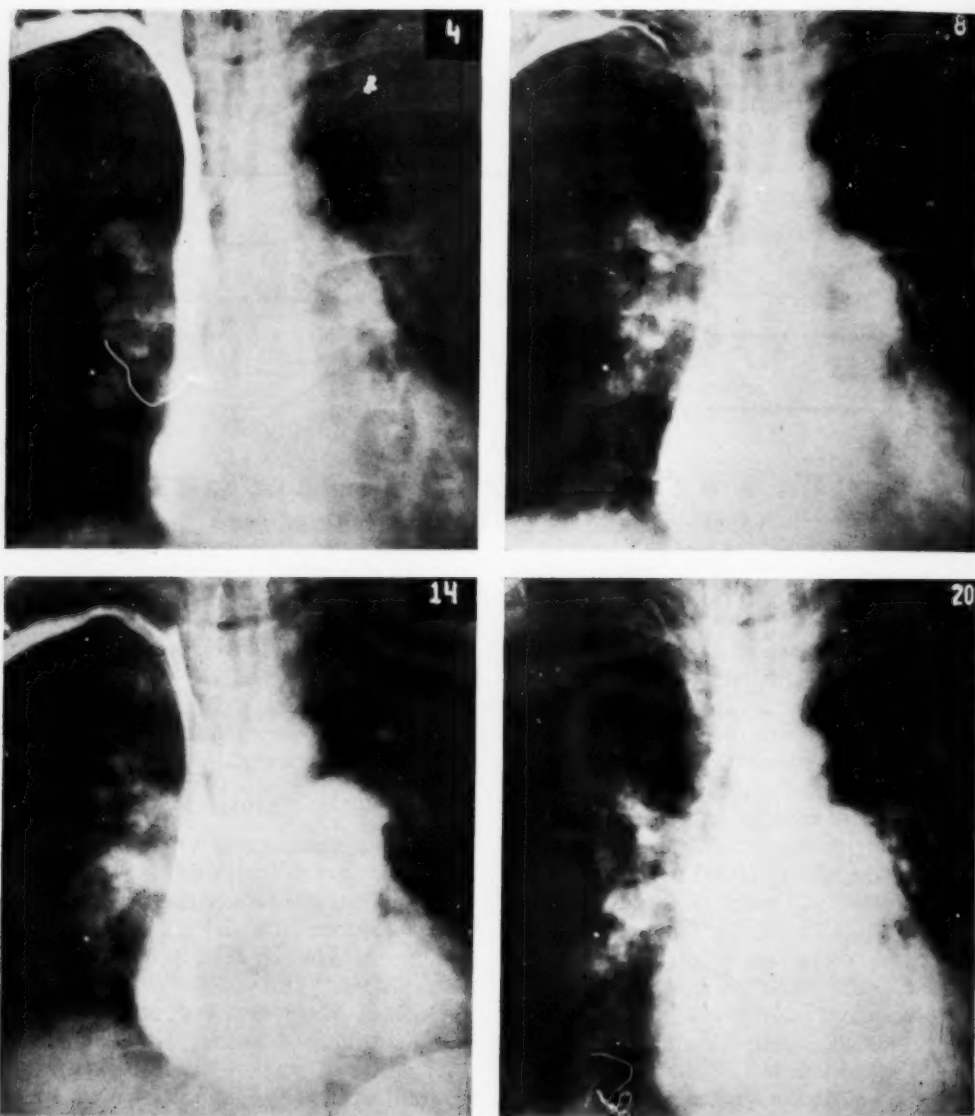


Fig. 8. Intermittent injection due to Valsalva effect. Filming speed, 2 per second. Initial entry of contrast on Film 4, aided by voluntary inspiration, has ceased by Film 8. With expiration, Film 14 (note position of diaphragm), a second bolus of contrast enters from pooling in the extrathoracic veins. As a result, recirculation to the right heart cannot be reliably detected.

period of vena caval filling, especially in children. A massive reflux is often seen with injection through the inferior vena cava (Fig. 9). An interesting ebb and flow of contrast is seen here, much like that which has been recorded in normal animal fetuses by cinematography. An

occasional normal adult shows a massive reflux, as seen in Figure 10. The reflux in this case suddenly cleared at nine seconds, presumably due to release of an unintentional Valsalva effort. Hedman, Lind and Wegelius (6), who presented the first analysis of the significance of hepatic



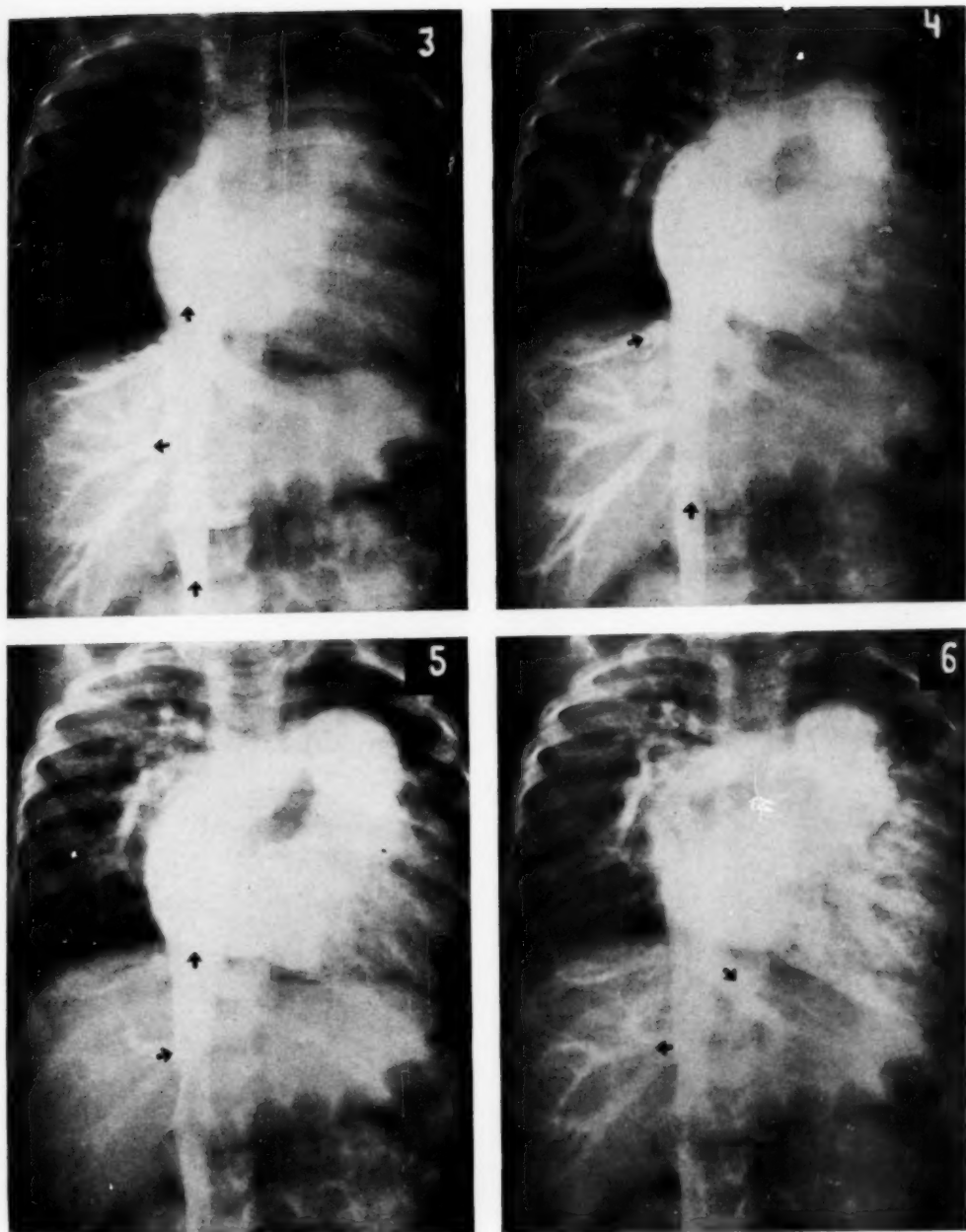


Fig. 9. Intermittent injection due to hepatic reflux. Female two years old, with patent ductus and moderate pulmonary hypertension. Films 2 per second. Contrast medium injected into a saphenous vein is filling the inferior vena cava, hepatic veins, and right heart on Film 3. It clears from the hepatic veins on Films 4 and 5, to return as a massive reflux on Film 6. Since the inferior vena cava is clearing at this time, this represents a true reflux from the heart. It is considered abnormal and resulted in intermittent entry of contrast medium into the heart as it returned later.

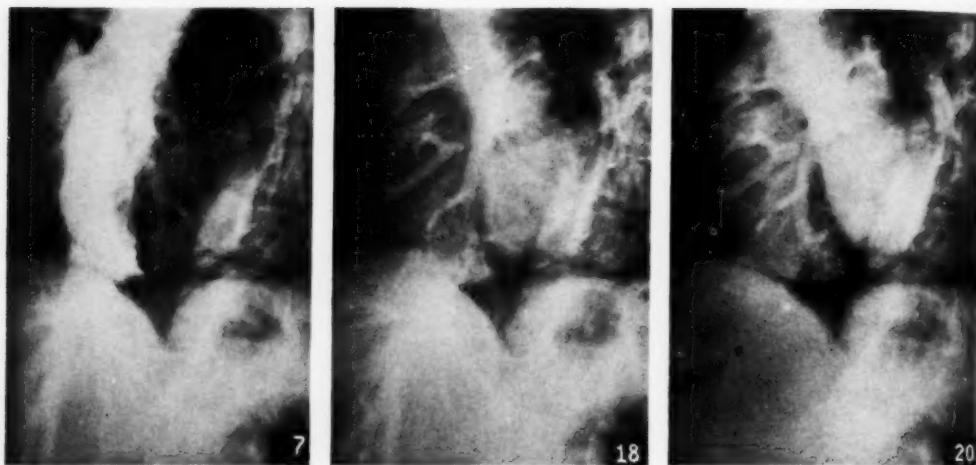


Fig. 10. Hepatic reflux in normal adult. Two films per second in left anterior oblique projection. Note the rapid clearing from the liver in one second, Films 18 to 20, probably due to the release of involuntary Valsalva effort. Detectable reopacification of the right heart is debatable.

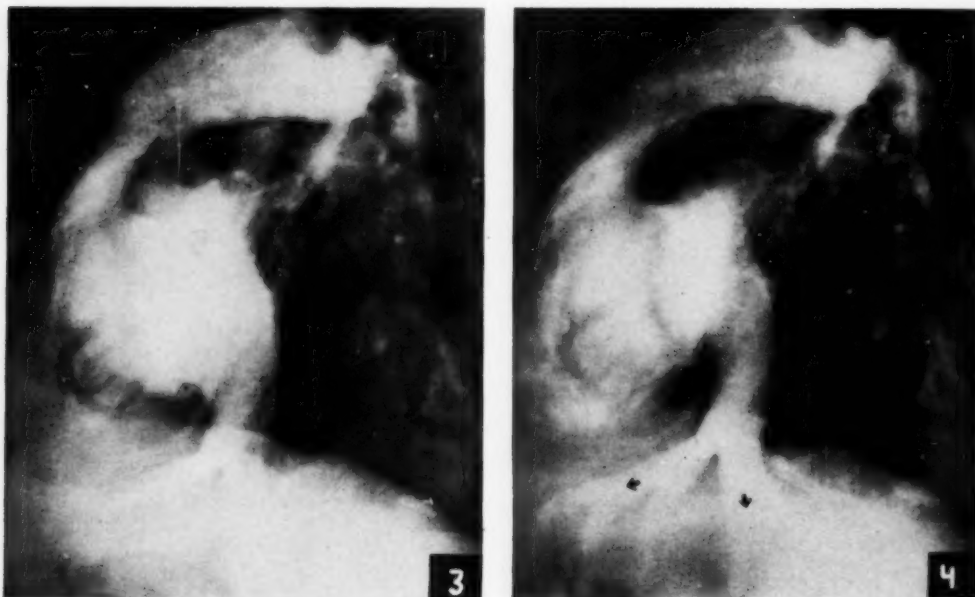


Fig. 11. Systolic hepatic reflux in normal adult. Chamber contours indicate right auricular diastole and right ventricular systole on Film 3. One-half second later, on Film 4, auricular systole and ventricular diastole are filmed. Note significant hepatic reflux during auricular systole. This may have been due to over-distention of the right auricle by an especially rapid injection as the superior vena cava has already cleared by one and a half seconds, Film 3.

refluxes, considered a reflux during atrial systole as abnormal, for normally the vena caval orifices are thought then to be closed. In this respect, Figure 11 shows a normal adult with an atrial systolic re-

flux. It seems safe to say that the significance of hepatic reflux has not yet been fully defined. We have recorded it in many conditions with enlargement of the right auricle: left-to-right shunts, pul-

monary hypertension, but most commonly in pulmonary valve stenosis. It would seem distinctly abnormal if it occurs after vena caval clearing when the pressure of injection has been dissipated.

Elimination of the undesirable effect of the Valsalva effort and standardization of injection ought to be obtained by automatic injection through an intracardiac catheter, as for selective angiocardiology (7). Preparations are being made for this in our department, and it is hoped that more decisive data can thus be obtained regarding circulation rate, recirculation, and hepatic refluxes.

A second defect inherent in the standard angiocardiology procedure is that filming of the heart of the infant and young child at two films a second is insufficiently rapid for recognition of minor alterations in circulation rate. At this rate the entire right heart circulation may be completed in the normal infant with only four films being obtained.

Probably the greatest defect lies in the lack of a record of the heart rate during filming. It is anticipated that the circulation time may be more meaningfully stated in terms of the number of cardiac cycles required for a given event. Simultaneous electrocardiography is performed in several laboratories (4, 11) and is now being used in this department to investigate this relationship.

Despite these shortcomings, this study has not proved entirely valueless. Some normal values have been defined for the circulation time by angiocardiology as it is usually practiced. Some delay in circulation can be related to pulmonary hypertension and pulmonary stenosis, particularly the latter. As a part of morphologic studies of cyanotic heart disease, others (8, 9, 10) have incidentally made these same observations. Similar prolongation of pulmonary artery opacity is seen with left-to-right shunts, but by contrast the aorta fills promptly, indicating the normally rapid pulmonary flow. In such an event, recirculation to the right heart can be suggested if injection has

been brief and not affected by Valsalva effort or hepatic reflux.

#### SUMMARY

As conventionally performed angiocardiology is affected by several uncontrolled variables which render it at best a crude record of the speed of intrathoracic circulation. Considerable implementation is necessary before circulation times can be meaningfully recorded and expressed. Nevertheless this survey of conventional angiocardiology experiences in congenital heart disease has shown delayed left heart opacification in most patients with pulmonary stenosis and some patients with pulmonary hypertension. The mechanisms involved for the retarded flow seen in several types of acquired heart disease have not been fully investigated.

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## SUMARIO

## La Significación de las Variaciones Angiocardiográficas del Tiempo de Circulación

Usando la angiocardigrafía con radiografías automáticas en serie a razón de 1.3, 2 y, raramente, 4 películas por segundo, los AA. llevaron a cabo estudios de la circulación normal y de enfermos con desviaciones de izquierda a derecha, estenosis de la válvula pulmonar, hipertensión pulmonar y coartación de la aorta. Quedó de manifiesto que la angiocardigrafía, según se ejecuta corrientemente, se ve afectada por varios factores variables y sin gobierno que la convierten, aun en las mejores circunstancias, en un registro tosco de la velocidad de la circulación intrato-

rácica. Esos factores variables conciernen a la inyección, la toma de radiografías y la falta de dominio sobre la velocidad cardíaca.

A pesar de dichas limitaciones este estudio reveló tardanza en la obtención de opacidad en el corazón izquierdo en la mayoría de los enfermos con estenosis de la válvula pulmonar y en algunos que tenían hipertensión pulmonar. No se han investigado plenamente los mecanismos que intervienen en el retardo de la corriente observado en varias formas de afección cardíaca adquirida.

## DISCUSSION

**Charles T. Dotter, M.D.** (Portland, Oregon): Dr. Figley's presentation has been interesting and stimulating. It points up the unreliability of circulating time tests as performed in the usual clinical manner.

Studies made in veins proximal to the site of angiocardigraphic injections have indicated that pressures up to 300 mm. of mercury are attained. These are dissipated upon reaching the mediastinum but may result in filling of collateral venous channels, a factor tending to result in slow clearance of in-

travenously injected substances from the cardiac chambers and great vessels. The frequent but erratic demonstration by angiocardigraphy of residual contrast substance trapped within the right ventricle should serve as indication that cardiac output studies based upon dye dilution curves are essentially unreliable.

Studies such as Dr. Figley's are of particular value in indicating the shortcomings of methods of investigation. May I congratulate him on his presentation?





## The Roentgen Study of the Chest in Measles<sup>1</sup>

JOHN De CARLO, JR., M.D., and HENRY H. STARTZMAN, JR., M.D.

THIS STUDY WAS undertaken after observation of a wide variety of roentgenographic chest changes in cases of measles and discovery in the American literature of only meager reference to this subject (1, 2). One hundred cases of measles seen at Baltimore City Hospitals in 1951-

2. Bronchopneumonic infiltration.
3. Large hilar shadows.
4. Intense pulmonary markings.
5. Pleuropulmonary changes (only 2 cases)
6. Widened mediastinum.
7. Atelectasis.

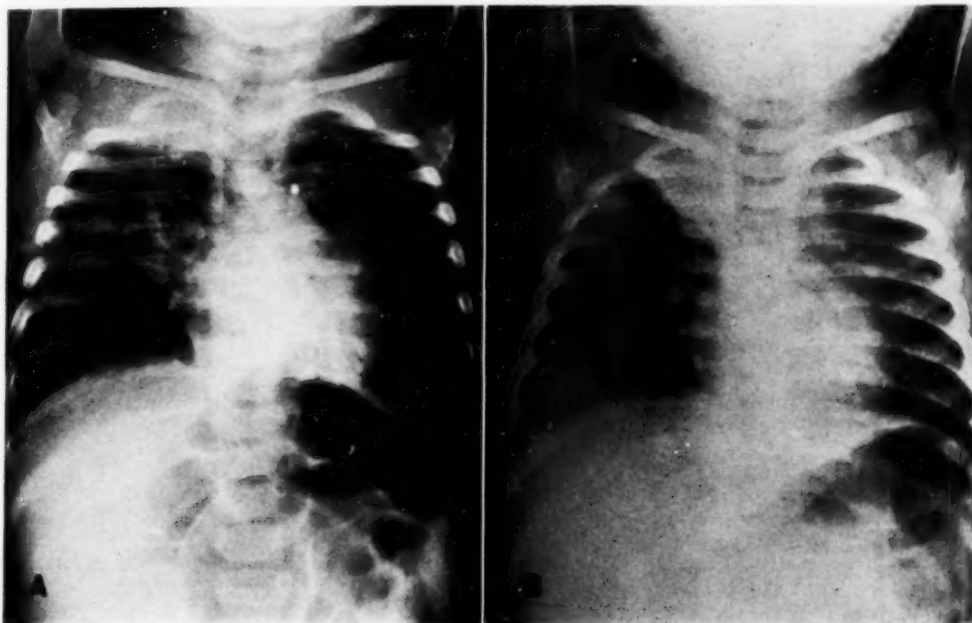


Fig. 1. Case I. A. Diffuse infiltration in the right upper lung field, with complete consolidation in the apical region. B. Five days later: right upper lobe pneumonia complicated by atelectasis.

52 were chosen at random for review. The patients were not currently under treatment but had been discharged months previously. Roentgenograms were available for only 60 patients, since a roentgen study was made only when clinically indicated.

### ROENTGEN OBSERVATIONS

The following radiographic changes were noted:

1. Localized infiltration.

A number of cases have been selected for the purpose of illustrating the above findings.

**CASE I:** An acutely ill 7-month-old white female was admitted to the hospital with a temperature of 106°. She had had a rash typical of measles for five days. One day prior to admission she became cyanotic and dyspneic, with severe coughing spells. The past history was negative except for frequent upper respiratory infections. No lymphadenopathy was noted.

The white blood cell count was 9,200, with a high lymphocytic component. Nasopharyngeal cultures were positive for hemolytic *Staphylococcus aureus*;

<sup>1</sup> From the Department of Roentgenology, Baltimore City Hospitals and University of Maryland, Baltimore, Md. Accepted for publication in October 1953.

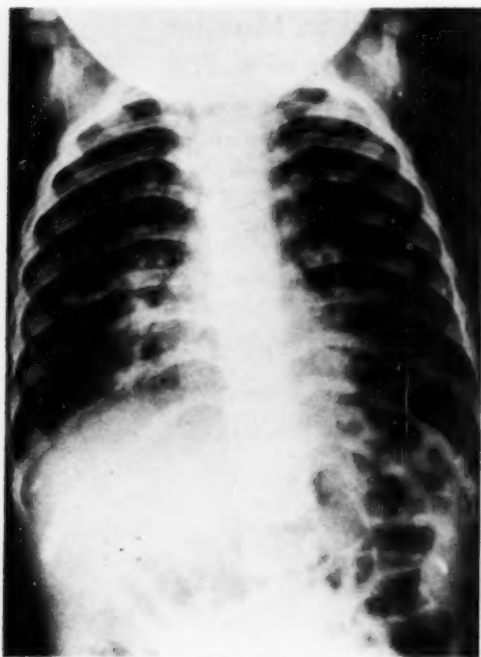


Fig. 2. Case II. Diffuse, fine, patchy infiltration throughout both lung fields, most pronounced in the cardiophrenic angles.

throat cultures were positive for *Diplococcus pneumoniae*.

A roentgenogram of the chest (Fig. 1A) taken on admission, because of positive pulmonary physical findings, showed diffuse infiltration in the right upper lung field, with complete consolidation in the apical region. The pulmonary markings were intense bilaterally. A chest film obtained five days later (Fig. 1B) showed right upper lobe pneumonia complicated by atelectasis.

Varying degrees of localized infiltration occurred in 18 of the 100 cases but in this one alone was progression to atelectasis observed.

**CASE II:** A 15-month-old white male who seven days prior to admission had a cough and coryza was admitted with a temperature of 104.6° and a rash which had developed on the day of admission. The child had had whooping cough and frequent upper respiratory infections. Physical examination revealed a moderate degree of cervical adenopathy and positive pulmonary findings.

The admission white blood cell count was 14,600, with a normal differential count. A nasopharyngeal culture was positive for *Staphylococcus aureus* and *Hemophilus influenzae*. The blood culture was negative.

Roentgenogram of the chest (Fig. 2) showed dif-

fuse, fine, patchy infiltration throughout, most pronounced in the cardiophrenic angles bilaterally.

This case is presented to demonstrate the bronchopneumonic type of infiltration. There were 13 cases of this type with varying degrees of infiltration, most marked in the cardiophrenic angles.

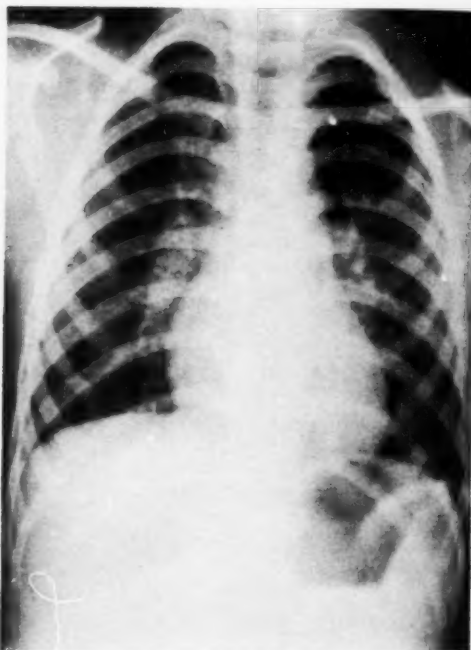


Fig. 3. Case III. Bilateral hilar enlargement with intense pulmonary markings.

**CASE III:** A 6-year-old white male with cough, fever, and a rash typical of measles for three days was admitted with a temperature of 102.4°. The past medical history was negative. Physical examination revealed cervical adenopathy and positive pulmonary findings. The admission white blood cell count was 4,000, with a normal differential count. Nasopharyngeal cultures were negative.

Roentgenogram of the chest (Fig. 3) showed bilateral hilar enlargement and intense pulmonary markings.

This case is presented to demonstrate hilar adenopathy. There were 22 such cases in the series; 12 were associated with parenchymal infiltration and 10 were without infiltration.

**CASE IV:** A five-year-old white male was admitted with a temperature of 104°. Two days prior to admission fever developed, followed by vomiting-

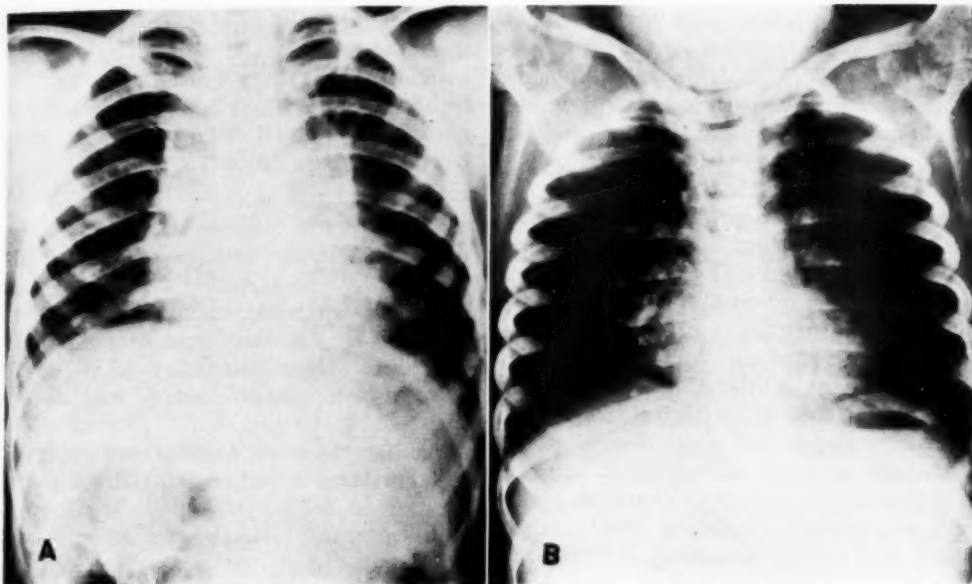


Fig. 4. Case IV. Tremendous hilar shadows and mediastinal widening. B. Regression of mediastinal adenopathy three days later.

convulsions, and Koplik's spots. The past medical history was negative.

Physical examination showed no evidence of cervical adenopathy, but chest findings made roentgenograms mandatory. The admission white blood cell count was 6,700 with a high polymorphonuclear component.

A roentgenogram of the chest (Fig. 4A) showed tremendous hilar shadows and mediastinal widening. Three days later (Fig. 4B) the mediastinal adenopathy had regressed.

This case demonstrates mediastinal and hilar adenopathy. Two other cases showed equivocal mediastinal widening.

Other roentgenographic findings consisted of pleuropulmonary changes and intense pulmonary markings. Two cases showed pleuropulmonary changes manifested by thickening of the pleura in the pulmonary fissures. Roentgenograms of these cases are not reproducible.

#### RESULTS

Of the 60 cases examined by chest roentgenography, 43 were interpreted as showing positive pulmonary findings. Thirty-one patients had parenchymal infiltration: in 18 this was localized; the remaining 13 had bronchopneumonia.

Ten cases showed large hili with otherwise negative chests. In 12 cases hilar enlargement was associated with parenchymal infiltration, either of the localized or bronchopneumonic type. A total of 22 of the 43 positive cases thus showed enlarged hili. There is a lack of correlation between clinically palpable nodes and roentgen manifestation of hilar and mediastinal adenopathies.

Two of the 43 positive cases were negative except for intense pulmonary markings. Many of the cases of pneumonic infiltration were associated with intense pulmonary markings.

Obviously, there is a great deal of subjective judgment involved in evaluating large hili and increased bronchovascular markings. An attempt was made to minimize this factor in the present study by excluding cases which in our judgment were equivocal.

#### COMMENTS AND DISCUSSION

None of the 100 cases of measles in this series resulted in death. Most patients with measles recover, and there is little in the way of pathologic material to study.

Pinkerton, Smiley, and Anderson (3), in a study of sections from 2 of 6 fatal cases of typical measles, describe the pulmonary lesions as identical with those of giant-cell pneumonia with nuclear cytoplasmic inclusions and other virus diseases. The measles pneumonia is compared with the interstitial pneumonia found in animals with virus distemper. This latter disease, occurring in minks, ferrets, and foxes, produces an interstitial pneumonia with giant-cell formation and typical cytoplasmic and nuclear inclusions. It is concluded that giant-cell pneumonia may be a lesion caused by the measles virus with or without the usual clinical manifestations of that disease. An alternative conclusion offered is that the giant-cell pneumonia is caused by another virus which may act independently or in association with the measles virus.

Goodpasture *et al.* (4) reviewed 5 cases of virus pneumonia in infants secondary to epidemic infection, especially measles and whooping cough. They feel that virus invasion is secondary to and paves the way for bacterial infection of the lungs. The presence of the virus was indicated by the occurrence of nuclear inclusions in the epithelial cells and mucous glands of the trachea and bronchi. Rapid necrosis of affected cells occurred, resulting in ulceration of the surfaces.

The conclusion is that there is an extreme histopathologic resemblance in the lesions of the lungs caused by virus infections. It is, therefore, not difficult to understand the similarity of the chest picture in these diseases.

#### SUMMARY

Available chest roentgenograms of 100 patients with measles revealed localized infiltration, bronchopneumonic infiltration, large hilar shadows, intense pulmonary markings, pleuropulmonary changes (2 cases), mediastinal widening, and atelectasis.

Similar roentgen findings are observed in other virus infections in children.

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#### SUMARIO

##### El Estudio Roentgenológico del Tórax en el Sarampión

Para 60 sarampionosos se contaba con radiografías torácicas corrientes. En 43 de éstas, la interpretación reveló alteraciones pulmonares, comprendiendo infiltración localizada, infiltración bronconeumónica, grandes sombras hiliares, intensas

marcas pulmonares, alteraciones pleuropulmonares (solamente en 2 casos), dilatación mediastínica y atelectasia.

Obsérvanse hallazgos roentgenológicos semejantes en niños que padecen de otras infecciones por virus.

## Plate Separation Requirements for Standard Free-Air Ionization Chambers<sup>1</sup>

FRANK H. ATTIX and LeROY DeLaVERGNE

FOR MANY YEARS the free-air ionization chamber has been the standard instrument for the measurement in roentgens of x-radiation doses below 200 kv. Agreement between the standard chambers of several national laboratories within about  $\pm 1$  per cent was established in 1931 by Taylor (1, 2), and the design of the standard chamber (3, 4) at the National Bureau of Standards has remained unchanged from that time until recently.

In 1952, Kemp and Hall (5) carried out a precise study of the lateral dimension requirements for complete utilization of electron ionization in a parallel-plate, variable-pressure air chamber. Their results indicated that the standard chambers at both the National Bureau of Standards (NBS) and the National Physical Laboratory (NPL) in England were inadequate in this respect, and that electric field distortion was responsible for the consistent under-estimation of plate separation requirements by other workers.

Preliminary measurements carried out in this laboratory early in 1953, with a large free-air chamber with improved distortion characteristics, indicated that even larger dimensions might be required than those predicted by Kemp and Hall. On the basis of this preliminary work, a temporary standard was constructed having plates 20 cm. in separation and 26.8 cm. in height. A comparison between this chamber and the old NBS standard chamber with x-rays of 200 kv. (constant potential) and medium filtration (0.52 mm. Cu plus 1.0 mm. Al) revealed that the old chamber was measuring about 2 per cent less ionization than the new one, in fair agreement with the predictions of Kemp and Hall.

A direct intercomparison between the National Physical Laboratory chamber

and the new National Bureau of Standards chamber was carried out at the National Physical Laboratory in June of 1953 (6). The NPL chamber was found to be subject to ionization losses of about 3 per cent at 195 kv. (constant potential), which was close to the results Kemp and Hall obtained with a replica of the NPL chamber. However, because of the disagreement between their work and the preliminary measurements made in this laboratory, and because their evidence placed in doubt the previously accepted free-air chamber design criteria, a broad study of the problem was undertaken. Both the field-distortion and the plate-separation characteristics of free-air chambers are being investigated in this laboratory for x-rays generated by potentials up to 500 kv. This present paper deals primarily with the plate-separation requirements for x-rays generated by potentials up to 250 kv.

The definition of the roentgen requires the measurement of all the ionization produced by electrons which themselves originate within a known volume of irradiated air. It is not practicable, however, to measure this ionization, since one cannot separate it from the ionization produced by other electrons originating in neighboring volumes of air which must of necessity also be irradiated. The free-air chamber overcomes this difficulty by utilizing the "electronic equilibrium" condition existing along the direction of the x-ray beam, as shown in Figure 1. The cross-hatched region represents the known volume in the sense of the roentgen definition. Its dimensions are established by the area of the limiting diaphragm, *D*, and the length of ion-collecting plate, *C* (assuming a uniform electric field). Ionization is collected throughout the region enclosed by the dashed lines. Some elec-

<sup>1</sup> This work was partially supported by the Atomic Energy Commission. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13-18, 1953.



trons such as  $e_1$ , having paths predominantly perpendicular to the x-ray beam, will expend their entire energies within the ion-collecting region, assuming the plate separation to be sufficiently large. (Actually, of course, the electron paths are not straight as indicated.) Others, like

method will be described for measurement of this ionization by scattered x-rays in free-air chambers.

Some mention should be made of the correction for air attenuation of x-rays in the distance  $d$  (see Fig. 1). Since the limiting diaphragm D determines the total

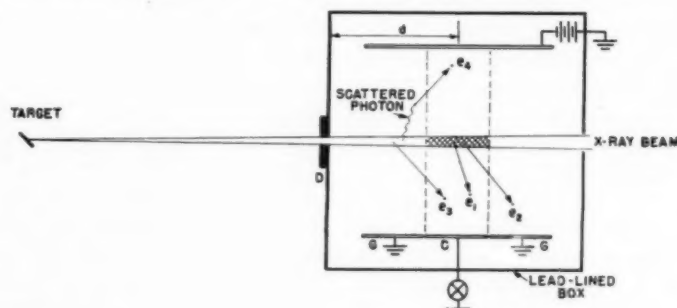


Fig. 1. Schematic plan view of a parallel-plate free-air ionization chamber.

$e_2$ , will pass out of that region and produce ionization where it will be collected on one of the guard-plates and hence will not be measured. Under the electronic equilibrium condition, this ionization loss is just compensated by the contribution of other electrons such as  $e_3$ , assuming air-attenuation of the primary beam to be small. Such a condition can exist only if the two ends of the box housing the chamber are at a distance (from the ion-collecting region) greater than the range of the electrons present, or about half the distance required for plate separation.

Electrons like  $e_4$ , resulting from scattered photons, produce ionization which is not included in the definition of the roentgen, since these electrons do not originate within the cross-hatched volume of air, nor do they compensate for ionization losses of other electrons that do. Their ionization contribution is usually assumed to be negligible. In large chambers, however, that assumption may not be justified. On the other hand, the presence of such unwanted ionization would tend to compensate for loss of electron ionization, (i.e. ionization produced by electrons which originate within the x-ray beam), due to insufficient plate separation. A

x-ray flux passing into the chamber, a free-air chamber measurement actually establishes the dose at the position of that diaphragm, except for the small attenuation of the beam in traversing the air between the diaphragm and the ion-collecting region.<sup>2</sup>

#### APPARATUS AND EXPERIMENT

*General Method:* The experiment consisted of three types of measurements for each kilovoltage and filtration:

1. Determination of the ionization produced in parallel layers of air, each 1 cm. in thickness, at various perpendicular distances from a narrowly collimated x-ray

<sup>2</sup> The effective length,  $d$ , of the absorbing air column is subject to some uncertainty, since it depends on the average center of origin of the electrons contributing to the ionization in the collecting region. Taking this position at the center of the collecting region assumes that electron ranges are short, or that their paths are homogeneous in direction forward and rearward. At higher x-ray energies, where forward-directed electrons predominate, the center of origin shifts toward the diaphragm and the effective air absorption column decreases in length. If the scattered-photon ionization in a chamber is measured and corrected for in the dose calculation, then to be consistent the total absorption coefficient should be used in the air absorption correction. That is, the coefficient should be experimentally determined by a method involving "narrow-beam" geometry, where the variable air column lies outside the narrowly diaphragmed chamber box, rather than by moving the plate system within the box.

beam, using a special experimental "grid" chamber.

2. Repeat of 1, except that a sheet of material (hereafter called the "electron filter") was interposed between the x-ray beam and the ion-collecting region to absorb all the electrons originating in the beam, but allow scattered x-rays to pass through with little attenuation, making it possible to differentiate between the two. By subtracting the ionization measured with the electron filter in place from that measured without the filter, the ionization was obtained for only the electrons originating in the beam, as required by the roentgen definition.

3. Measurement of the ionization produced in a conventional free-air chamber by the same x-ray beam used in the first two types of measurements. This was done to provide a figure for the ionization integrated over the entire ionized volume, so that the previous measurements of ionization in various parts of the volume could be expressed as fractions of the whole.

From these measurements it was possible to calculate the percentage by which the ionization produced by electrons from the x-ray beam in a free-air chamber would be decreased by inadequate separation of the parallel plates.

*The Grid Chamber:* Figure 2 is a plan view of the experimental ionization chamber. It was housed within a lead-lined box, A, 70 cm. long  $\times$  33 cm. wide  $\times$  39 cm. high. The electrode system was positioned along one side wall of the box and consisted of a graphite plate, K, for collecting the ionization, surrounded by co-planar guard plates, J. In front of the collector were two parallel grids of graphite-coated nylon thread, L, which defined the volume in which ionization was collected (shaded area). The first row of threads was 1 cm. from the collector plate, and was operated at  $\approx 135$  volts, which was found to be ample to avoid ion recombination in the collecting volume. The second row was at ground potential to give a more clearly defined collecting volume by reducing the "bulging" of field

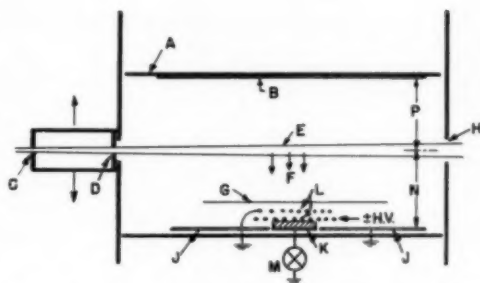


Fig. 2. Plan view of grid chamber. A. Lead box 70 cm. long, 33 cm. wide, 39 cm. high. B.  $1/16$ -inch Lucite lining, graphite-coated. C. Defining diaphragm, 1 cm. in diameter, 76 cm. from tube target. D. Scatter diaphragm, 1.8 cm. in diameter, 17 cm. from defining diaphragm. E. Collimated x-ray beam, approximately 1.8 cm. in diameter, at position opposite collecting electrode. F. Electrons and scattered photons. G. Electron filter, 1.7 mm. polystyrene, graphite-coated and connected to ground; positioned 2 cm. from outer grid. H. X-ray beam exit hole, 7.4 cm. in diameter. J. Aluminum guard plates, 18 cm. long and 33 cm. high, graphite-coated. K. Graphite collecting electrode, 10 cm.  $\times$  24 cm.  $\times$  5 mm. L. Graphite-coated nylon threads. M. Vibrating reed electrometer. N. Beam to plate distance, variable from 4 to 22 cm. P. Distance of beam from opposite wall, variable from 24 to 6 cm.  $P + N$  is constant at 28 cm.

lines between the threads of the first row.

The front and back walls of the lead box were fixed in position, as was the x-ray beam, E. The remainder of the box, including the electrode system, was mounted on a track at right angles to the x-ray beam, allowing variation of the distance N, from the x-ray beam to the collector plate, over the range from 4 to 22 cm. The distance  $P + N$  to the wall opposite the electrode system was 28 cm. That wall and the top and bottom of the box were lined with  $1/16$  inch graphite-coated Lucite, B, to minimize electron back-scattering.

The electron filter, G, consisted of a sheet of graphite-coated polystyrene 1.7 mm. in thickness, electrically connected to ground. When in place, this filter stopped all electrons approaching the collecting volume from outside the filter, but allowed scattered photons to pass through with negligible attenuation. When the filter was removed, both electrons and scattered photons were allowed to pass.

Most of the electrons stopped by the filter originated within the x-ray beam. Hence, the difference between the two

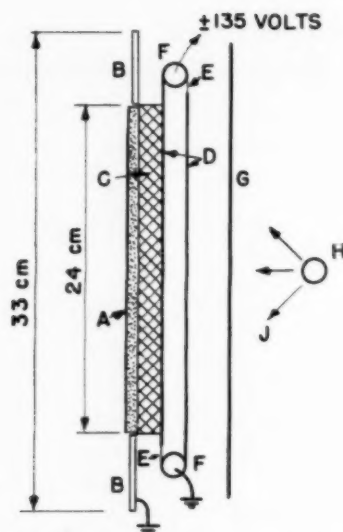


Fig. 3. Grid-chamber electrode system, viewed from rear. A. Graphite collecting electrode. B. Graphite-coated aluminum guard plates. C. Ion collecting volume,  $1 \times 10 \times 24$  cm. D. Graphite-coated nylon threads in two rows 1 cm. apart. Separation of threads in each row 5 mm., with 30 threads per row. Thread diameter, 0.2 mm. E. Part of each thread not covered by graphite, to provide insulation. F. Graphite-coated aluminum rods, 0.5 inch in diameter, supporting the nylon threads. Rods are cut with a spiral groove of 5 turns to the inch, to position the threads properly. Distance between axes of the two rods, 29.4 cm. G. Electron filter, graphite-coated polystyrene. H. X-ray beam. J. Electrons and scattered photons.

measurements (filter in, filter out) approximately represents ionization produced by electrons of the roentgen definition. However, the filter also intercepted some electrons produced outside the beam (and outside the filter position) by scattered photons. These electrons were partially replaced by those ejected from the inner surface of the filter itself. As will be seen from the data in Figure 4, such compensation was not complete at 100 kv. (or at lower kilovoltages) where photoelectric effect in the air made the filter material slightly non-air-equivalent. It was possible to correct for this, as will be discussed further in relation to Figure 4.

Figure 3 is a detail drawing of the grid chamber electrode system, indicating its dimensions and the mounting of the threads. Actually the grids were made of only one long nylon thread which was

wound around spiral grooves in the two aluminum rods, F. This thread was then painted with alcohol "dag" in such a way as to leave the parts E bare, to serve as insulators, and to connect the inner row of threads to the upper rod and the outer row to the lower rod. External electrical connections were then made to the rods themselves.

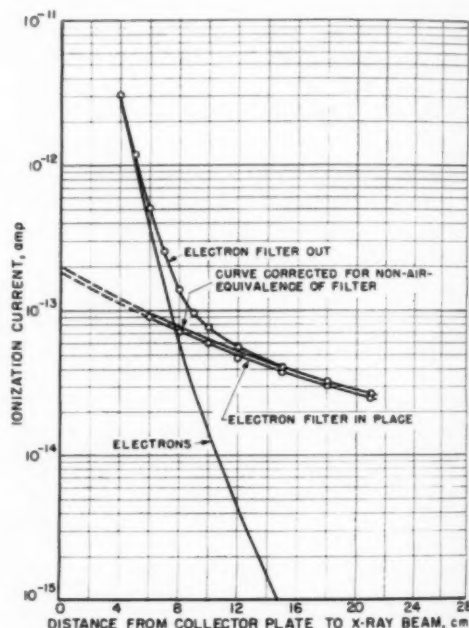


Fig. 4. Grid-chamber current vs. distance from x-ray beam; 100 kv., medium filtration (1.02 mm. Al). Standard free-air chamber current:  $4.73 \times 10^{-10}$  amp.

The collector plate was made of graphite, so that it would be nearly air-equivalent from the standpoint of electron back-scattering. To determine the magnitude of this effect, the graphite was replaced with aluminum in one instance for 200-kv. x-rays with medium filtration. The ionization measured with the electron filter in place was about 60 per cent greater than for the graphite plate, because of photoelectric effect in the aluminum. However, the calculated results for electron ionization losses in free-air chambers, based on the aluminum plate data, did not differ appreciably from those calculated from the graphite plate data except

at small distances from the x-ray beam, as is shown in Table II. Hence, since electron scattering varies roughly as  $Z^3$ , one may assume that the experimental results are not significantly influenced by back-scatter of electrons from the graphite collector plate.

*The Standard Free-Air Chamber:* Measurement of the ionization integrated over the entire ionized volume was made by means of the present NBS standard chamber mentioned earlier. Plate separation was 20 cm., plate height 26.8 cm. The limiting diaphragm diameter (1 cm.) and the collector plate length (10 cm.) were the same as in the grid chamber. The standard chamber was located on one side of the grid chamber with the limiting diaphragms of the two chambers in the same plane. The x-ray tube housing was mounted on a track running at right angles to the beam direction and could thus be positioned in alignment with either chamber. Standard chamber readings were made in conjunction with each grid chamber run, the x-ray tube output being constant.

One might ask why the standard chamber reading was necessary, since it would seem possible to get the total ionization by merely summing up the grid chamber measurements over the whole volume. This was prohibited by the fact that the grid chamber plate system could not be moved closer to the x-ray beam than about 6 cm. with the electron filter in place, or 4 cm. without it. Closer positioning would have caused the beam penumbra to strike the grids or filter. Thus it was not possible with the grid chamber to make measurements in the most densely ionized central region.

Small errors in the standard chamber itself, such as might be caused by slight insufficiency in plate separation, would have a negligible effect on the subsequent calculations of ionization losses.

A detailed description of this standard chamber will be the subject of a later paper.

*Measurement of Ionization Current:* A vibrating reed electrometer was used as a

null-detecting device for the current measurements. Currents larger than about  $10^{-12}$  ampere were passed through calibrated multi-megohm resistors and the resulting IR drop compensated by a potentiometer connected in series. For smaller currents, a compensating rate-of-charge method was employed, the charge being collected on a calibrated capacitor which was an integral part of the electrometer.

All measurements were carried out at atmospheric pressure and room temperature, approximately 755 mm. Hg and 26° C. respectively.

The ionization currents measured in the grid chamber with different polarities of voltage on the inner grid were generally not identical in magnitude, since there was some ionization generated by scattered x-rays in the region behind the collecting electrode. There the grid potential had no influence, but contact-potentials served to collect ionization. This extra-cameral ionization was corrected for by measuring the current with both polarities and averaging the two values. The unwanted current is added in one case and subtracted in the other, and is thus cancelled out.

*X-Ray Apparatus and Beam Filtration:* A 250-kv. x-ray tube enclosed in a thick lead housing was employed for this work. The high-voltage generator supplied an essentially constant potential, having a ripple not exceeding 0.6 per cent. Kilo-voltage and tube current were continuously monitored during operation and were, by manual adjustment, maintained at a constant value within  $\pm 0.1$  per cent.

The inherent filtration of the x-ray tube was equivalent to approximately 3 mm. Al. Additional filtration<sup>3</sup> was placed at the 1.27-cm. diameter portal in the tube housing, located 16 cm. from the target. In Table I are given the added filtrations used at various kilovoltages, together with the copper half-value layers of the filtered beams.

<sup>3</sup> The "heavy" filtrations were essentially those of M. Ehrlich and S. H. Fitch: *Nucleonics* 9: 5-17, September 1951. Note error in their Table 4, p. 16: 150 kv. filter should be 1.53 mm. Sn and 4 mm. Cu.



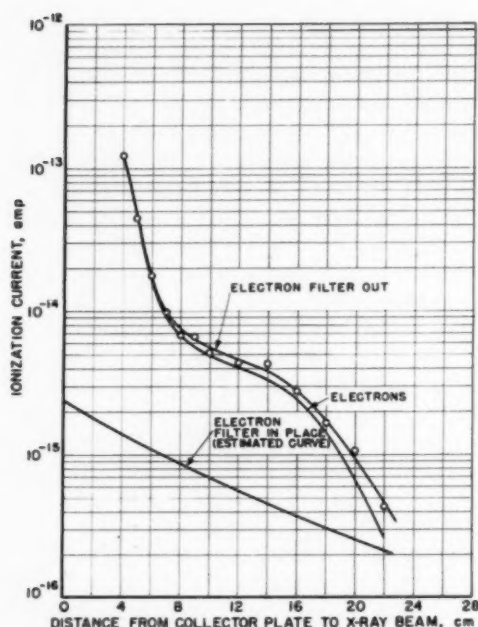


Fig. 5. Grid-chamber current vs. distance from x-ray beam; 200 kv., heavy filtration (0.7 mm. Pb + 4.0 mm Sn + 0.59 mm. Cu). Standard free-air chamber current:  $1.076 \times 10^{-11}$  amp.

TABLE I: X-RAY BEAM CHARACTERISTICS

Kilovolts Constant Potential	Added* Filtration (mm.)	Copper h.v.l. (mm.)
<i>Medium</i>		
60	None	0.077
75	None	0.099
100	1.02 Al	0.176
150	.228 Cu + 1.02 Al	0.60
200	.52 Cu + 1.02 Al	1.23
250	1.02 Cu + 1.02 Al	2.14
<i>Heavy</i>		
100	0.53 Pb	0.77
150	1.53 Sn + 4.00 Cu	2.42
200	0.70 Pb + 4.00 Sn + 0.59 Cu	4.03
250	2.70 Pb + 1.00 Sn + 0.59 Cu	5.28

\* Inherent filtration: 3 mm. Al.

#### EXPERIMENTAL RESULTS AND CALCULATIONS OF ELECTRON IONIZATION LOSSES

Figures 4 to 7 are given as examples of the ionization vs. distance curves obtained with the grid chamber. Included are curves for 100 kv., medium filtration; 200 kv., heavy filtration; 250 kv. with

both medium and heavy filtration. The filters used were those that are listed in Table I. The electron curves have been determined by a point-by-point subtraction of the filter-in curve from the filter-out curve.

The extrapolated range of 100 kev.

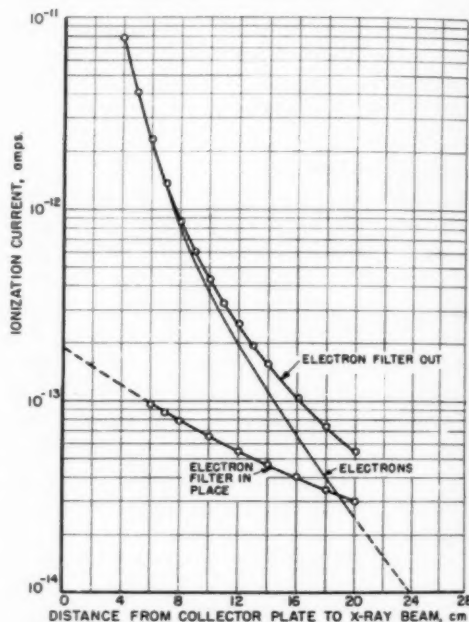


Fig. 6. Grid-chamber current vs. distance from x-ray beam; 250 kv., medium filtration (1.02 mm. Cu + 1.02 mm. Al). Standard free-air chamber current:  $7.82 \times 10^{-10}$  amp.

electrons in air at atmospheric pressure is given in the literature (7) as 12 cm. Compton recoil electrons produced by 100-kv. x-rays will have energies not exceeding 28 kev., and thus ranges less than 2 cm. This identifies the electrons producing the curve in Figure 4 as photoelectrons. Therefore, the bend in the upper curve clearly shows the transition from electron ionization to that resulting from scattered x-rays. Beyond 15 cm. the "filter-in" and "filter-out" curves are seen to be parallel and at a constant separation, even though the lower curve has been corrected for attenuation of scattered photons in the filter. They should coincide beyond the 12-cm. range of the electrons



from the x-ray beam. The observed discrepancy is probably caused by the lack of air equivalence of the electron filter material, as was mentioned previously. It is corrected for by raising the lower curve parallel to itself until it coincides with the upper one at large distances.

Figure 5, presenting ionization curves for 200-kv. x-rays with heavy filtration, also has a bend in the "filter-out" curve. In this case, however, the "filter-in" curve lies well below it, and thus photon scattering cannot account for the abrupt change in slope. The cause becomes evident if one again considers the types of electrons present. For the x-ray wave lengths present in the primary beam, the absorption coefficient for air will consist of about 2 per cent photoelectric effect and 98 per cent Compton effect. The range of the maximum-energy photoelectrons will be about 37 cm., while the range of the most energetic Compton electrons (88 kev.) will be 9 cm. Thus the change in the slope of the curves of Figure 5 at 9 cm. represents the transition from Compton electrons to the longer-range photoelectrons.

It should be mentioned in regard to Figure 5 (and all other cases of heavy x-ray filtration) that the lower curve, for electron filter in place, had to be estimated in an indirect way. The background current in the grid chamber was of the order of  $10^{-16}$  amperes and was sometimes unsteady, making it very difficult to obtain reliable measurements of ionization currents of that order of magnitude or smaller. Hence, it was thought preferable to estimate the curve in the following way: The slope was taken in each case to be the same as for the corresponding medium x-ray filtration, since these were found to be about the same for all energies. Then the curve was adjusted to a position such that twice the area under the curve out to 10 cm. was in agreement with the total scattered photon contribution measured in the 20-cm. standard free-air chamber by a method to be described. This was assumed to be proper, since a similar

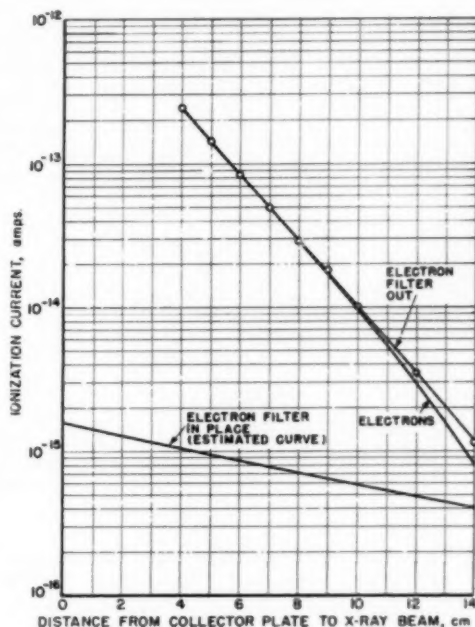


Fig. 7. Grid-chamber current vs. distance from x-ray beam; 250 kv., heavy filtration (2.7 mm Pb + 1.0 mm. Sn + 0.59 mm. Cu). Standard free-air chamber current:  $8.89 \times 10^{-12}$  amp.

comparison between scatter measurements in the free-air chamber and grid chamber showed generally good agreement for the medium x-ray filtrations.

In Figure 7, representing the ionization curves obtained with heavy filtration at 250 kv., the bend observed in Figure 5 has disappeared. The photoelectric effect in air is negligible here, and the ionization is almost entirely produced by Compton electrons. Their energies will not be in excess of 123 kev., and hence their ranges extend to only about 15 cm., which appears to be consistent with the curves in Figure 7.

It is thus apparent that the plate separation requirements for 200 kv. with heavy filtration are greater than for 250 kv. because of the disappearance of the photoelectric effect in air at the latter energy.

*Calculation of Electron Ionization Losses:* For each kilovoltage and filtration the electron ionization losses caused by insufficient plate separation in free-air cham-

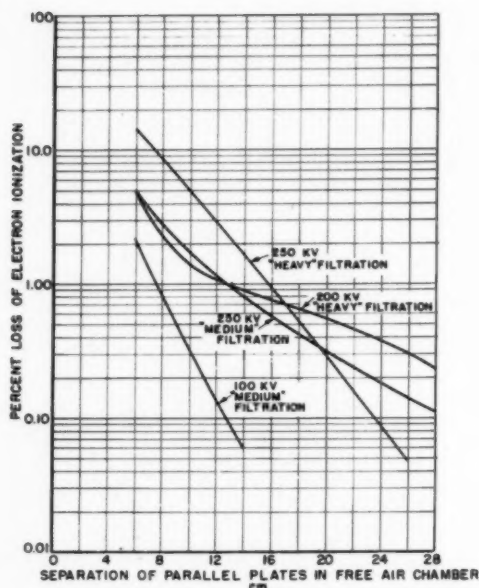


Fig. 8. Electron ionization losses in parallel-plate free-air chambers with adequate plate height.

bers were calculated by means of the following formula:

Per cent ionization loss =

$$\frac{(100) (1.087) (2) \sum_{d=1}^{\infty} (I_{ef0} - I_{ef1})}{I_{sc}}$$

where

$I_{ef0}$  = grid chamber ionization current with the electron filter out.

$I_{ef1}$  = grid chamber ionization current with the electron filter in place.

$I_{sc}$  = corresponding ionization current in the standard free-air chamber

$d$  = variable distance (cm.) from collector plate to x-ray beam in the grid chamber.  $d - 1 = s/2$ , where  $s$  is the free-air chamber plate separation for which the ionization loss is being computed. 1 is subtracted from  $d$  to account for the 1 cm. depth of the grid chamber collecting volume.

The factor (2) is included because the grid chamber measures the ionization on only one side of the x-ray beam. The (1.087) is a correction factor which accounts for the area covered by the nylon threads, which stop the electrons that strike them.

The summation sign indicates that the electron current is summed up, for layers each 1 cm. in thickness, from distance  $d$  out to infinity. Beyond the outermost data the electron ionization curves were simply assumed to continue with unchanging slope.

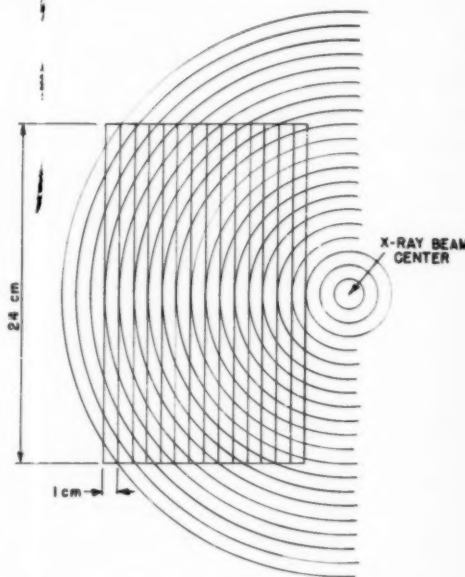


Fig. 9. Drawing similar to that used for planimeter measurements to determine the ionization densities existing in cylindrical shells coaxial with the x-ray beam.

In Figure 8 are plotted the resulting ionization losses for the curves in Figures 4 to 7. Table II contains data for all kilovoltages studied.

It should be noted that in the calculations the diameter of the x-ray beam is not considered, and the distances are reckoned from the central axis of the beam. Thus the results are most accurate when applied to chambers having x-ray beams of about the same diameter (1.8 cm.) as was used here.

Thus far, only the losses resulting from inadequate plate separation have been discussed, and no mention has been made of plate height, which is of course of equal importance. A chamber should be designed with both of those dimensions sufficiently large to allow nearly all the

TABLE II: PER CENT ELECTRON IONIZATION LOSSES FOR VARIOUS PLATE SEPARATIONS IN A FREE-AIR CHAMBER

Plate Separation (cm.)	60 kv. med. filt.	75 kv. med. filt.	100 kv. med. filt.	100 kv. heavy filt.	150 kv. med. filt.	150 kv. heavy filt.	200 kv. med. filt.	200 kv. med. filt.*	200 kv. heavy filt.	250 kv. med. filt.	250 kv. heavy filt.
6	0.2 <sub>7</sub>	0.8 <sub>0</sub>	2.2	6.4	4.3	3.9	4.9	5.5	4.8	5.0	14.5
8	<0.05	0.2 <sub>0</sub>	0.8 <sub>1</sub>	3.2	2.1	3.1	2.6	2.9	2.3	2.9	8.5
10		<0.05	0.3 <sub>2</sub>	1.5	1.2	2.5	1.6	1.8	1.4	1.8	4.9
12			0.1 <sub>3</sub>	0.6 <sub>7</sub>	0.6 <sub>9</sub>	1.9	1.0	1.2	1.1	1.1	2.8
14			0.0 <sub>4</sub>	0.2 <sub>8</sub>	0.4 <sub>3</sub>	1.5	0.7 <sub>2</sub>	0.8 <sub>1</sub>	0.8 <sub>9</sub>	0.7 <sub>8</sub>	1.7
16			<0.05	0.1 <sub>2</sub>	0.2 <sub>8</sub>	1.1	0.5 <sub>1</sub>	0.5 <sub>9</sub>	0.7 <sub>8</sub>	0.5 <sub>8</sub>	0.9 <sub>4</sub>
18				0.0 <sub>7</sub>	0.1 <sub>8</sub>	0.8 <sub>2</sub>	0.3 <sub>7</sub>	0.4 <sub>3</sub>	0.6 <sub>3</sub>	0.4 <sub>2</sub>	0.5 <sub>3</sub>
20				<0.05	0.1 <sub>2</sub>	0.5 <sub>9</sub>	0.2 <sub>7</sub>	0.3 <sub>3</sub>	0.5 <sub>8</sub>	0.3 <sub>1</sub>	0.2 <sub>8</sub>
22					0.0 <sub>5</sub>	0.4 <sub>1</sub>	0.1 <sub>9</sub>	0.2 <sub>3</sub>	0.4 <sub>4</sub>	0.2 <sub>4</sub>	0.1 <sub>4</sub>
24					0.0 <sub>5</sub>	0.2 <sub>8</sub>	0.1 <sub>1</sub>	0.1 <sub>9</sub>	0.3 <sub>8</sub>	0.1 <sub>8</sub>	0.0 <sub>5</sub>
26					<0.05	0.1 <sub>3</sub>	0.1 <sub>0</sub>	0.1 <sub>1</sub>	0.3 <sub>0</sub>	0.1 <sub>4</sub>	<0.05
28						0.1 <sub>2</sub>	0.0 <sub>4</sub>	0.1 <sub>2</sub>	0.2 <sub>3</sub>	0.1 <sub>1</sub>	
30						0.0 <sub>7</sub>	0.0 <sub>4</sub>	0.0 <sub>9</sub>	0.1 <sub>7</sub>	0.0 <sub>8</sub>	
32						<0.05	<0.05	0.0 <sub>7</sub>	0.1 <sub>3</sub>	0.0 <sub>7</sub>	
34								0.0 <sub>4</sub>	0.0 <sub>9</sub>	0.0 <sub>4</sub>	
36								<0.05	0.0 <sub>4</sub>	<0.05	

\* The data in this column were obtained with a bare aluminum collecting plate in place of the graphite plate normally used in the grid chamber. They illustrate the magnitude of the effect of electron back-scattering on the results.

electrons projected radially outward from the x-ray beam to run their full ranges without leaving the ion-collecting volume, either by striking the plates at the sides or by escaping out the top and bottom. The data in Table II represent losses caused by plate separation inadequacy alone, assuming the plate height to be adequate. What constitutes adequate plate height is complicated by field distortion, as pointed out by Kemp and Hall (5). The collecting volume may be defined as the region occupied by the electric field lines which terminate on the collector plate. This region will be considerably smaller in effective height than the plates themselves if the field is not properly guarded from the effects of the grounded chamber enclosure. The actual cross-sectional shape of the collecting volume of a particular chamber, in a plane at right angles to the x-ray beam, is obtainable from a study of field lines in an electrolytic tank.

It was thought to be desirable to convert the data in Table II into a more general form which could be applied to any free-air chamber in which the cross-sectional shape of the collecting volume was known. A graphical method was found for doing this.

The graph used in this calculation was

similar to that shown in Figure 9, but drawn to a large scale. The ionization field was assumed to be made up of concentric cylindrical shells each 1 cm. in thickness and containing a uniform ionization density. The superimposed rectangles, 24 cm. in height and 1 cm. in thickness, represent various positions of the grid chamber collecting volume. By first taking planimeter measurements, the unknown ionization densities in the cylindrical shells were deduced from the known electron ionizations in the grid chamber volume. It was then possible to calculate how much of the ionization lay outside of any given radius, *i.e.*, the ionization that would be lost by a cylindrical chamber of that radius, positioned coaxially with the beam. Table III gives the results of such calculations. To apply these results to any chamber for which the cross-sectional shape of the collecting volume is known, it is necessary to plot the cross section on polar-coordinate graph paper, with the x-ray beam located at the origin. The ionization losses are then obtained from Table III for a number of representative radii on the plot, weighted according to the angular sector they represent, and summed to give the total ionization loss.

A calculation of this sort was carried

TABLE III: PER CENT LOSSES OF ELECTRON IONIZATION OUTSIDE OF VARIOUS RADII FROM THE X-RAY BEAM

Radius (cm.)	60 kv. med. filt.	75 kv. med. filt.	100 kv. med. filt.	100 kv. heavy filt.	150 kv. med. filt.	150 kv. heavy filt.	200 kv. med. filt.	200 kv. heavy filt.	250 kv. med. filt.	250 kv. heavy filt.
3	0.7 <sub>7</sub>	2.1	4.9	12.9	8.9	6.0	9.7	10.4	9.9	27.7
4	0.1 <sub>6</sub>	0.5 <sub>8</sub>	2.0	7.6	4.7	5.3	5.5	5.0	6.1	18.1
5	<0.05	0.1 <sub>5</sub>	0.8 <sub>8</sub>	4.1	2.7	4.6	3.5	2.9	4.0	11.5
6		<0.05	0.3 <sub>7</sub>	2.0	1.6 <sub>5</sub>	3.9	2.3	2.2	2.7	7.2
7			0.1 <sub>7</sub>	0.8 <sub>7</sub>	1.0 <sub>5</sub>	3.3	1.7	1.8	1.9	4.4
8			0.0 <sub>5</sub>	0.3 <sub>5</sub>	0.7 <sub>4</sub>	2.6 <sub>5</sub>	1.3	1.6	1.4	2.7
9			<0.05	0.2 <sub>5</sub>	0.5 <sub>1</sub>	2.1	0.9 <sub>4</sub>	1.4	1.1	1.6
10				0.1 <sub>2</sub>	0.3 <sub>5</sub>	1.6	0.7 <sub>2</sub>	1.3	0.8 <sub>5</sub>	0.9 <sub>7</sub>
11				0.0 <sub>5</sub>	0.2 <sub>4</sub>	1.2	0.5 <sub>5</sub>	1.1	0.6 <sub>5</sub>	0.5 <sub>5</sub>
12				0.0 <sub>5</sub>	0.1 <sub>7</sub>	0.8 <sub>5</sub>	0.4 <sub>2</sub>	1.0	0.5 <sub>5</sub>	0.3 <sub>5</sub>
13				<0.05	0.1 <sub>2</sub>	0.6 <sub>2</sub>	0.3 <sub>2</sub>	0.8 <sub>7</sub>	0.4 <sub>4</sub>	0.1 <sub>5</sub>
14					0.0 <sub>5</sub>	0.4 <sub>2</sub>	0.2 <sub>4</sub>	0.7 <sub>2</sub>	0.3 <sub>5</sub>	0.0 <sub>5</sub>
15					0.0 <sub>5</sub>	0.2 <sub>5</sub>	0.1 <sub>5</sub>	0.5 <sub>7</sub>	0.3 <sub>5</sub>	<0.05
16					<0.05	0.1 <sub>5</sub>	0.1 <sub>4</sub>	0.4 <sub>4</sub>	0.2 <sub>5</sub>	
17						0.1 <sub>5</sub>	0.1 <sub>1</sub>	0.3 <sub>2</sub>	0.2 <sub>5</sub>	
18						0.0 <sub>5</sub>	0.0 <sub>5</sub>	0.2 <sub>5</sub>	0.1 <sub>7</sub>	
19						<0.05	0.0 <sub>5</sub>	0.1 <sub>2</sub>	0.1 <sub>1</sub>	
20							<0.05	0.1 <sub>5</sub>	0.1 <sub>2</sub>	
21								0.0 <sub>5</sub>	0.1 <sub>5</sub>	
22								<0.05	0.0 <sub>5</sub>	

out to determine the adequacy of the 24 cm. height of the collector plate in the grid chamber, and the effect on the data in Table II. In the worst cases (250 kv., medium filtration; 200 kv., heavy filtration), the tabulated percentage losses in Table II were found to be too small by about 0.2 per cent for figures of 1 per cent or larger, and by 0.1 per cent or less for figures below 1 per cent. The data in Table III are not subject to this error, since the actual collector plate height of the grid chamber was taken into account in the calculation of those data.

The ionization contributed by scattered x-rays in a particular free-air chamber will depend not only upon the plate separation and height, but also upon the length of the irradiated air column within the chamber enclosure; thus, this ionization cannot be conveniently tabulated. It was therefore considered preferable to describe a method by which the ionization by scattered x-rays can be directly determined with sufficient accuracy in any given chamber.

A tube of nearly air-equivalent material such as Lucite, extending the full length of the chamber enclosure, is positioned inside the chamber so that the x-ray beam passes through it from end to end. The

tube must have walls thick enough to stop the electrons, but thin with respect to attenuation of scattered x-rays. The plastic should be made conducting with a graphite coating, and operated at half the potential of the high-voltage plate, to minimize field distortion. The x-ray beam is narrowly collimated to prohibit the penumbra from producing excess scatter by striking the walls of the tube, which should be as small in diameter as practicable. The ratio of ionization measured with the tube in place to that with it removed will give the fraction of the total ionization that is contributed by scattered x-rays. Since most of the electrons have short ranges (see Table III), the normal distribution of electrons generated by scattered x-rays in the chamber will not be significantly disturbed by the presence of the tube. A small error will be produced by the "shadowing" effect of the tube, since it collects the ionization produced between it and the high-voltage plate, prohibiting that ionization from arriving at the collector plate. This can be corrected with sufficient accuracy by simply taking into account the collecting volume lost by the effect. Details of the application of this method to the NBS standard chamber will be included in a later paper; however, the



ionization from scattered x-rays in that chamber was found to constitute 0.3 to 0.4 per cent of the total ionization, increasing slowly with decreasing energy.

The net ionization loss of a free-air chamber is found by subtracting the measured contribution due to scattered x-rays

TABLE IV: COMPARISON OF PREDICTED AND MEASURED DEFICIENCIES FOR PARALLEL PLATE CHAMBERS (24-cm. plate height)

Free-Air Chamber Plate Separation (cm.)	Measured Ionization Deficiency (per cent)	Ionization* Deficiency from Grid-Chamber Data (per cent)
6	4.9	5.0
7	3.5	3.6
8	2.7	2.7
9	2.1	2.1

\* These figures have been raised by 0.1 per cent to account for the estimated difference in scattered photon ionization in the 20-cm. standard chamber and the test chamber.

from the appropriate figures for loss of electron ionization as given in Tables II and III.

#### COMPARISON OF GRID-CHAMBER RESULTS WITH OTHER MEASUREMENTS

Two chambers were constructed whose predicted ionization losses (from grid-chamber results) were large because of inadequate dimensions. Care was taken to avoid field distortion in these chambers. The actual deficiency was then determined experimentally for 200-kv. x-rays with medium filtration by comparison with the 20-cm. standard chamber. In the latter chamber, electron losses and scattered photon contributions compensate one another within about 0.05 per cent at that energy.

Table IV gives the results for a chamber of 24 cm. height and separations from 6 to 9 cm. Table V gives similar data for a chamber 10 cm. in height and the same range of separations. Agreement with grid chamber predictions is good in both cases.

In the light of these results and other considerations, the limits of error of the electron loss data in Tables II and III are estimated to be  $\pm 0.3$  per cent, except for

TABLE V: COMPARISON OF PREDICTED AND MEASURED DEFICIENCIES FOR PARALLEL PLATE CHAMBERS (10-cm. plate height)

Free-Air Chamber Plate Separation (cm.)	Measured Ionization Deficiency (per cent)	Ionization* Deficiency from Grid-Chamber Data (per cent)
6	6.0	5.8
7	4.7	4.7
8	3.9	3.9
9	3.3	3.3

\* These figures have been raised by 0.15 per cent for the reason noted in Table IV.

the grid chamber plate height inadequacy, which affects only Table II. The loss figures are probably within closer limits of error at larger plate separations, where the losses themselves are decreased.

*Comparison With Results of Kemp and Hall:* The results of the measurements of Kemp and Hall (5) are expressed as ionization losses in chambers having square cross sections of various sizes. These ionization loss figures are compared with corresponding figures from the present investigation in Table VI, for 100-kv. x-rays.

TABLE VI: COMPARISON WITH WORK OF KEMP AND HALL

"Square" Chamber Dimensions (cm.)	Ionization Losses of Kemp and Hall, 100 kv.p. (per cent)	Electron Ionization Losses from Grid Chamber Measurements 100 kv. Constant Potential (per cent)
9.6 $\times$ 9.6	<0.1	0.7
7.4 $\times$ 7.4	0.5	1.9
6.5 $\times$ 6.5	1.0	3.0

It is evident that large differences exist between the two sets of data, the ionization losses of Kemp and Hall being smaller than ours. Similar discrepancies were found to exist at the other kilovoltages. The most important factors contributing to these differences are:

- (1) Difference in quality of the x-rays used. The copper half-value layer obtained by Kemp and Hall<sup>4</sup> at 100 kv.p. was 0.078 mm. as compared

<sup>4</sup> Figure supplied by Kemp (8).



with our value of 0.176 mm. Kemp and Hall used a Villard circuit and 2 mm. Al inherent filtration, where we used a constant potential generator and 3 mm. Al inherent filtration.

- (2) Difference in x-ray beam diameter. Kemp and Hall employed a beam about 1 cm. in diameter, as compared with our 1.8 cm.

Charlton (9) are essentially in agreement with the present grid-chamber data, since it would have been unlikely that they could have detected by their method the very small increments of ionization existing at greater separations. Their ionization chamber was relatively free from electric field distortion at separations up to 18 cm., because of the long guard plates (25 cm.),

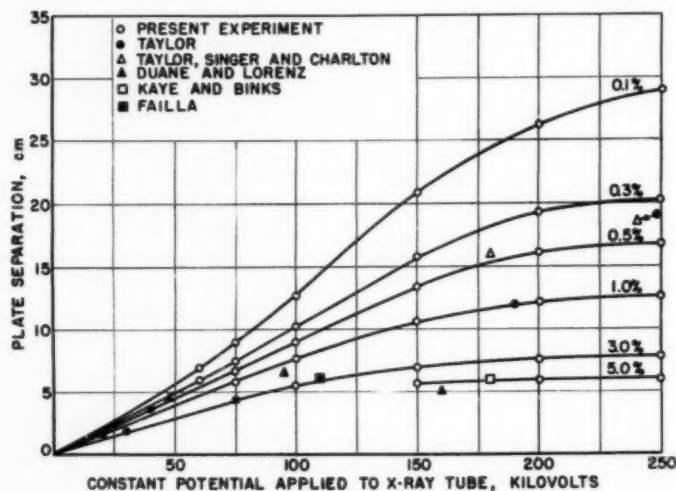


Fig. 10. Comparison with results of other workers for medium x-ray filtrations and constant potentials. The curves are drawn through points obtained in the present experiment, each curve indicating the plate separations at which equal losses of electron ionization occur for various kilovoltages. The other points represent separations at which other workers observed "complete" collection of ionization (see Footnote 5).

*Comparisons With the Work of Others:* To facilitate comparisons with other experiments at kilovoltages differing from those used for the present experiment, a graph of plate separation vs. kilovoltage is given in Figure 10 for medium x-ray filtration. Also plotted on this graph are the points at which complete collection of ionization was observed by other investigators.<sup>5</sup>

The results of Taylor, Singer and

the large collecting plate height (35 cm.), and a system of guard wires, all enclosed in a tank of ample dimensions (65 cm. diam.  $\times$  213 cm. length). The other data of Taylor (10) were given as part of a general survey paper, and were not all obtained with an individual chamber. The point at 240 kv. was taken from Reference 9. The other data were taken in two other chambers, each of which is now known, in the light of recent developments, to have been subject to considerable field distortion, accounting for the low values obtained for the separations.

The same explanation also applies to the

<sup>5</sup> All used the method of varying the plate separation while observing the ionization current. Complete ionization collection was assumed to exist at the point where no detectable increase in ionization was observed with further increase in separation. Their methods did not differentiate between electron ionization and that produced by scattered x-rays, but simply measured the total of the two. Constant potential kilovoltages were used in every case. Filtrations were not given except by Duane and Lorenz (12), who used 2

mm. Al at 95 kv. but did not state the filtrations for other kilovoltages, and by Failla (13), who used 0.1 mm. Cu and 2.15 mm. Al at 110 kv. One may assume that a medium or light filtration was employed in all the other instances.

results of Kaye and Binks (11), Duane and Lorenz (12), and Failla (13).

Failla's work was particularly interesting, inasmuch as he made a careful study of the field distortion existing within his chamber. His collecting plate was divided into eleven adjacent vertical strips, each 3.8 cm. wide, so that he could measure the ionization in various volumes along the x-ray beam. He found that the ionization currents collected by several of the centrally located strips were the same, and that the closer the plate separation, the larger the number of adjacent strips collecting the same current. This was interpreted as an indication of the region over which no field distortion was present. One could equally well interpret the same facts as showing the region over which the distortion produced the same error in each strip. The latter would seem to be the case, since, in another measurement, Failla varied the plate separation from 6 to 20 cm. and measured a constant current output from the central strip out to 15 cm. separation. Our present work shows that the current should have increased by about 3 per cent over this range of separations, for 110-kv. x-rays with medium filtration. Hence, the effective collecting volume of the central strip probably decreased by about 3 per cent because of worsening field distortion. This has been substantiated by preliminary measurements of field distortion by Miller and Kennedy in this laboratory.

The field-distortion problem is thus seen to be much more serious than has been heretofore supposed, and new criteria must

be established for designing distortion-free chambers. This problem is now under investigation.

ACKNOWLEDGMENT: The authors wish to express their appreciation to Dr. H. O. Wyckoff for many helpful discussions relating to this work.

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Washington 25, D. C.

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#### SUMARIO

#### Los Requisitos para la Separación de Placas en las Camaras Corrientes de Yonización al Aire Libre

Se describe un método para medir las pérdidas de yonización debidas a la inadecuada separación de las placas paralelas en las cámaras al aire libre. La yonización producida por los rayos X esparcidos del haz colimado fué medida por separado y restada del total para obtener el aporte de

yonización derivada solamente de los electrones del haz. Tabúlanse las pérdidas de esa yonización electrónica para separaciones de 6 a 36 cms. en las placas, con rayos X moderada o intensamente filtrados, procedentes de un tubo de 50 a 250 kv. de potencial constante. Los resultados se

convierten además en forma coordinada cilíndrica para aplicación a cámaras distintas de las de cámaras paralelas. Sugiérese un método para medición, en otras

cámaras al aire libre, del aporte de yonización por rayos X esparcidos. Compáranse los resultados en pérdida de yonización con experimentos anteriores.

#### DISCUSSION

**John W. Beattie** (Chicago, Ill.): I am sure we are all familiar with the work of the National Bureau of Standards and its reputation for accuracy, completeness and competence in its investigations. This paper follows the tradition.

If you should go back to 1938, to a very extensive investigation by Taylor, Singer and Charlton published in the *NBS Journal of Research* and in the *American Journal of Roentgenology*, you would not be surprised at the statement of Kemp which led to this study. However, this investigation is more than a check on previous investigations, because the ionization produced by absorption of Compton photons has been isolated from that produced by secondary electrons in the standard chamber. I do not believe that this has been done before, and in this respect a certain amount of error in the measurement of the standard chamber had not been previously eliminated.

In closing, I would like to say that refinements such as this allow us to add more significant figures to our accuracy from time to time, and to us physicists this is always stimulating.

**L. D. Marinelli:** Although the work presented by Mr. Attix shows that this particular type of error is not too large beyond certain minimum chamber dimensions, free-air chamber experiments by Mr. Kemp and others in Europe have shown that in standardization of x-ray equipment by means of the ionization chamber, there may be a serious accumulation of errors. Maximum differences between standard laboratories of the order of 8 per cent have been noted, and the errors have been found to originate not only in the size of the chamber but also in such trivial details as connections to condensers and instability of condensers used in the measurement.



## The Scintillation Limit in Fluoroscopy<sup>1</sup>

JOHN W. COLTMAN, Ph.D.

THE ULTIMATE performance which can theoretically be obtained with a fluoroscopic imaging device is determined by the quantum nature of the x-rays themselves. In medical fluoroscopy, the available x-ray intensity is set by the permissible patient dose, so that the information carried by the x-rays is quite definitely limited. This fact was first pointed out by R. C. Mason (1) in 1944. Since then, experimental work and calculations have been carried out by several others. The limitation has usually been expressed in terms of the minimum brightness gain of an ideal intensifier in which the perception is limited by the scintillation effect rather than by the observer's eye. Mason estimated that the scintillations would be noticeable at a brightness gain of about 10, and expressed serious doubt as to whether very large brightness gains (*i.e.* 10,000) would be of interest. An experimental test of the effect was carried out for a particular case by Coltmán and Ebbighausen (2, 3). Under conditions equivalent to a gain of 5,000, they found that the contrast discrimination for small objects was not seriously impaired by the quantum noise. Morton (4), in discussing the photon limitations of the eye, ventured the opinion that in x-ray image amplification there was little point in going beyond a gain of 10, since no further information could be obtained from the x-rays. Sturm and Morgan (5), in a more elaborate analysis, arrived at a figure of 50 to 100.

With the advent of the first operable image amplifier tubes (6), it became possible to prove directly that at brightness gain of 50 times, no measurable loss in visual acuity could be ascribed to the scintillation effect. At this brightness gain, the visual acuity was still limited by the eye rather than by the instrument. Thus it became certain that some of the early

estimates of the scintillation limit were unduly pessimistic.

Though Sturm and Morgan's work can be revised to yield a very much higher gain figure when certain previously neglected considerations are taken into account, the subject still remained in a very unsatisfactory state, first because of the wide variance of conclusions, and second because all of the methods were more or less indirect and employed extrapolations and assumptions which had not been adequately tested.

The research reported here was undertaken to make a direct determination of the capabilities of an ideal fluoroscope limited only by quantum fluctuations. The problem resolves itself into two parts: first, a determination of the number of significant x-quanta available at the screen; second, a determination of the ability of the eye to integrate a scintillating picture into a meaningful pattern. With these data the performance of an ideal image intensifier over the entire range of fluoroscopic conditions can be predicted.

### DETERMINATION OF AVAILABLE QUANTA

In the various works cited above, it has been customary to calculate the number of quanta available by converting  $r$  units into quantum densities. This procedure is subject to two criticisms: first, the spectral distribution of the x-rays (necessary for the conversion) is inadequately known, and second, the  $r$  measurement ordinarily includes a considerable amount of scattered radiation which does not contain information as to the location of the shadow-producing objects.

For these reasons, a direct measurement of the number of quanta available was made by means of a scintillation counter using a sodium iodide crystal and a 5819 photomultiplier. A deep slit, 0.0065 inches

<sup>1</sup> From Westinghouse Research Laboratories, East Pittsburgh, Penna. Accepted for publication in June 1954.

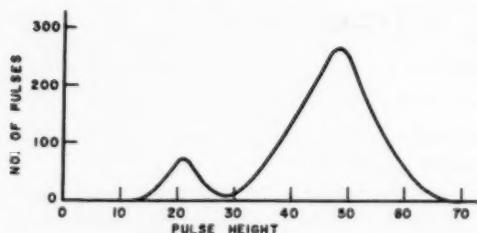


Fig. 1. Distribution of pulse heights from the scintillation counter excited by 80-kv. x-rays.

A comparison of r-meter readings with the counting rate gave a value of  $2.8 \times 10^8$  quanta per square millimeter per r unit. While this is some 10 per cent higher than that calculated from the absorption coefficients of air and the energy required to produce an ion pair, the agreement was considered satisfactory for the present purposes.

The detector with the slit fixed on its

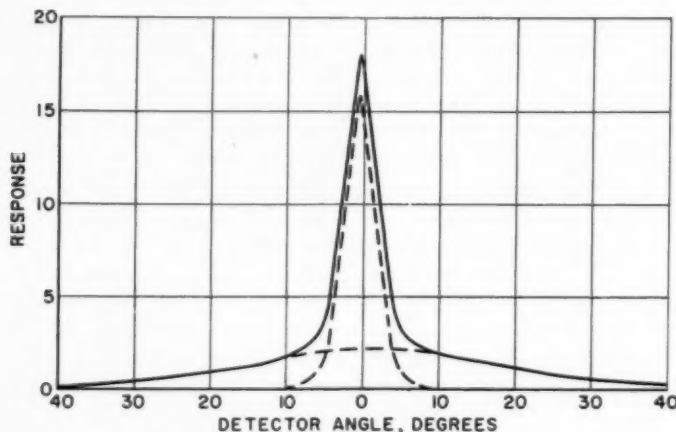


Fig. 2. Intensity of radiation as a function of detector angle for the geometry of Fig. 3. The peak is unscattered radiation; the broad background is due to scattering in the thick phantom.

wide, 0.0623 inches long, and 0.083 inches deep (*i.e.* in the direction of the x-ray beam), made of type metal, restricted the angular view of the detector to  $\pm 4.5$  degrees. The scintillation counter was followed by the usual linear amplifier, discriminator, and fast scaling circuit, capable of operating at pulse rates over 30,000 per second. The scaler was later replaced by a simple counting rate meter.

Figure 1 shows the distribution in height of the pulses from the scintillation counter when excited by x-rays of 80 kv. constant potential with 2 mm. of copper filter. The small peak is ascribed to the escape of iodine fluorescent radiation from the crystal, which would give rise to pulses lacking 30 kev. energy. The curve is quite clean, and at discriminator settings below 10 it is apparent that each x-quantum entering the crystal is counted.

end was arranged in the screen yoke of a fluoroscope in a fixture that permitted rotation of the detector about a horizontal line passing through the slit perpendicular to the x-ray beam. The response could thus be obtained as a function of the angle of arrival at the detector. In the absence of any scattering material, the response versus angle is triangular, as expected from the geometry of the slit. When a scattering material is introduced into the beam, the response versus angle consists of a triangle due to the unscattered radiation, plus a slowly varying background due to scattered radiation originating in the sample off the axis of the beam.

A typical curve is shown as the solid line in Figure 2. The background has been smoothly extrapolated through the central region, and subtracted to give the dotted curve of unscattered radiation. It



will be seen that in the case illustrated, with a detector accepting only  $\pm 4 1/2$  degrees of angle, a 12 per cent correction must be made for scattered radiation. A comparison of the areas under the two curves indicates that with a detector accepting large angles, only 45 per cent of the total reading would be ascribable to unscattered radiation.

Figure 3 shows the geometry of the fluoroscope for the case cited. The phantom is of presdwood having a density of 1.085. This material closely approximates the absorption and scattering of flesh in that 1 cm. of presdwood is equivalent on the average to 1 cm. of solid tissue. The

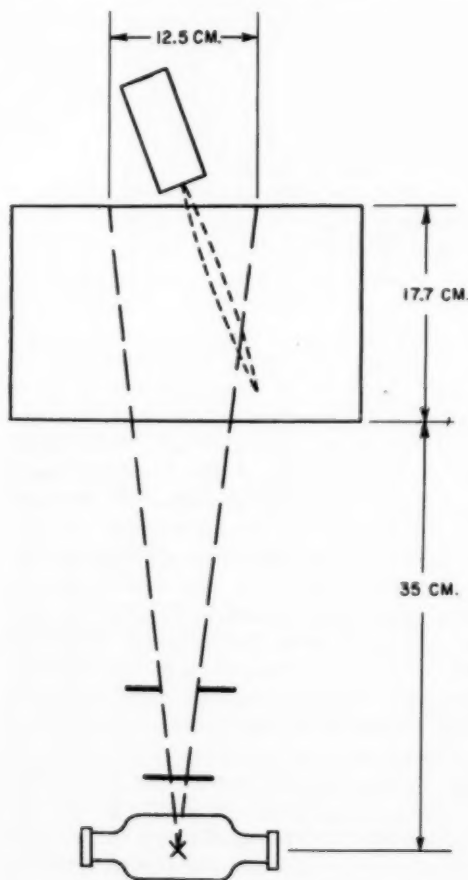


Fig. 3. Geometry of phantom, x-ray tube, and detector. The broken loop is a polar diagram of the detector sensitivity as a function of angle.

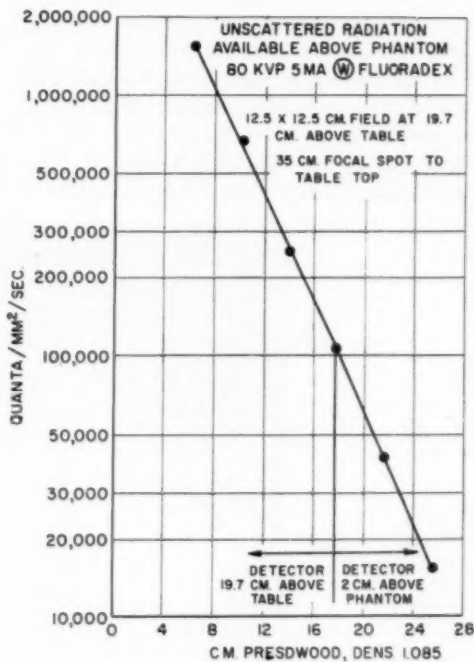


Fig. 4. Quanta available in fluoroscopy. Scattered radiation has been eliminated. Except for phantom thickness and detector position, the geometry is as given in Fig. 3.

17.7 cm. thickness of presdwood represents a 7-inch abdomen. The broken-line loop extending from the detector in Figure 3 is a polar diagram of the angular response of the slit, to illustrate the acceptance angle of the detector. The shutters near the x-ray tube were adjusted to give a  $12.5 \times 12.5$ -cm. field at a screen distance of 19.7 cm. above the table top.

At each of several phantom thicknesses a curve similar to that of Figure 2 was obtained. For phantom thicknesses greater than 17.7 cm. the detector was moved back so as to remain 2 cm. above the top of the phantom; at thicknesses less than 17.7 cm. the detector distance was held constant at 19.7 cm., corresponding to the normal limitation of motion in the fluoroscope. The maximum counting rate was corrected for the residual scattered radiation as shown in Figure 2 and converted to quanta per square millimeter per second. The resulting curve is shown in Figure 4. The

x-ray conditions for these data were 80 kv.p. (calibrated with an accurate sphere gap), full wave rectified, 5 ma., with 1 mm. of aluminum and 0.0035 inches of phosphor bronze (equivalent to about 1.5 mm. of aluminum additional) as a filter.

A similar curve taken with a large r-

rived from an x-ray source, as shown in Figure 5. The scintillation counter already described was mounted behind a long vertical slit. In front of this was rotated a square-toothed wheel opaque to x-rays, so that when a tooth obscured the lower part of the slit, a decrease in the scintillation

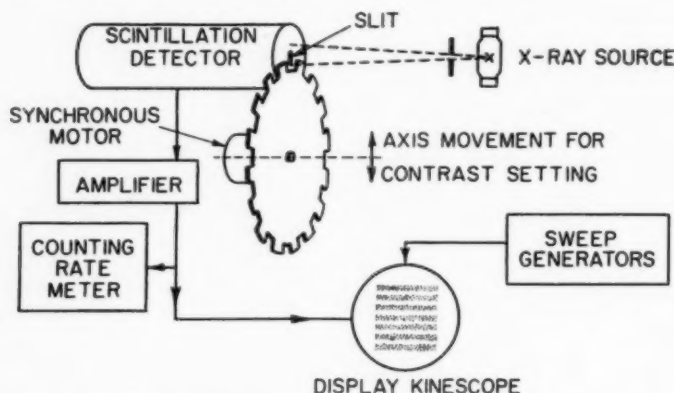


Fig. 5. The ten-line test pattern displayed on a kinescope was generated by random scintillations from an x-ray source, modulated in intensity by a toothed wheel, which could be raised or lowered in front of a slit to vary the contrast.

meter chamber has a noticeably smaller slope and gives a calculated number of quanta about four times higher than the curve of Figure 4 at a phantom thickness of 18 cm. Thus the inclusion of scattered radiation in the  $r$  measurement gives an erroneous impression of the number of useful quanta available for image formation, the error varying with patient thickness.

#### THE EYE AS AN INTEGRATOR

An ideal image intensifier would receive only information-bearing x-ray signals from the subject and construct therefrom an image of arbitrary size and brightness. Neither size nor brightness would then limit the eye's ability to recognize the content of the picture. It is, of course, also postulated that the ideal image intensifier would introduce no unsharpness of itself and that the x-ray image is perfect except for quantum fluctuations.

Such an ideal apparatus was simulated by displaying on a television kinescope a bar pattern delineated by bright dots de-

rate resulted. Output pulses from the scintillation counter were amplified and applied to the video portion of the television set. The wheel speed and television scan rates were so adjusted as to give ten bright stripes with nine dimmer (or properly speaking, less densely populated) stripes between them. By raising or lowering bodily the rotating wheel, the contrast of the pattern could be changed. Thus, when the outer rim of the wheel just coincided with the lower end of the slit, no change in x-rays was effected by the passage of the teeth and the contrast was zero; when the teeth cut off half the slit, the contrast was 50 per cent; when the wheel was adjusted to cut off the entire slit, the contrast was 100 per cent. Figure 6 shows the general appearance of these patterns.

This arrangement provided an accurate simulation of an ideal x-ray intensifier examining a small area of picture containing a resolving-power grid of adjustable contrast. The "population," or number of flashes per unit time, was varied by chang-

ing the x-ray intensity and was measured with a counting rate meter in the output of the pulse amplifier, while pattern contrast was accurately determined over the entire range by the wheel position. Obviously magnification and x-ray intensity are interchangeable, that is, a pattern with

scription of the experiment, together with a discussion of the implications of the results with respect to the fluctuation theory of contrast perception, has been published elsewhere (7). For purposes of the computation, median values of the measured points of Figure 7 were chosen as listed in

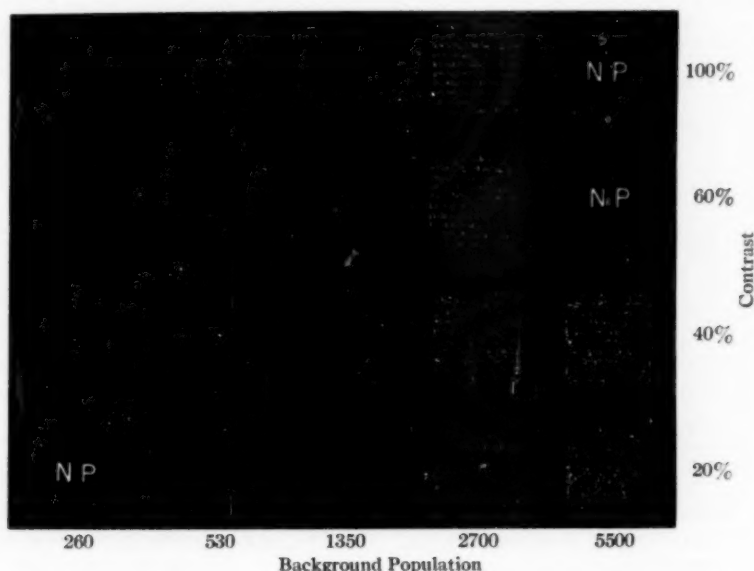


Fig. 6. Photographs of patterns on the kinescope. The rows are labeled in pattern contrast, the column labels give the number of flashes the entire still picture would contain at zero contrast. No photographs were taken for the positions marked "NP."

a population of 100,000 flashes per second and showing 10 lines could be considered as a representation of a square area 1.0 mm. on a side with an x-ray intensity of 100,000 quanta/mm.<sup>2</sup>/sec., or as an area 5 mm. on a side with an x-ray intensity of 4,000 quanta/mm.<sup>2</sup>/sec. In the first case the pattern represents 10 lines/mm., in the second case 2 lines/mm., measured at the object.

With this apparatus, a determination was made, over a wide range of populations, of the pattern contrast necessary for recognition of the presence of a pattern. Four observers with normal eyesight were tested in a manner which assured an objective evaluation of their ability to discern the pattern. The results obtained are given in Figure 7. A more detailed de-

scription of the experiment, together with a discussion of the implications of the results with respect to the fluctuation theory of contrast perception, has been published elsewhere (7). For purposes of the computation, median values of the measured points of Figure 7 were chosen as listed in

Background Population Flashes per Second	Contrast Required for Perception
900	100%
2000	70%
5000	50%
12,500	35%
50,000	20%
130,000	14%
270,000	10%

The results obtained here demonstrate a very remarkable ability of the eye to dis-

tinguish a pattern among the scintillations. The reader may satisfy himself with respect to this point and check roughly the observations, by a scrutiny of Figure 6. The background populations quoted under the columns are for the still picture; the corresponding live-picture population in

imaging system is here given for a wide range of image contrasts and phantom thicknesses. The limiting resolving powers are surprisingly high. Even at a 20-cm. phantom thickness, the ultimate resolution for a 100 per cent contrast object is 80 lines/mm., roughly 15 times that of prac-

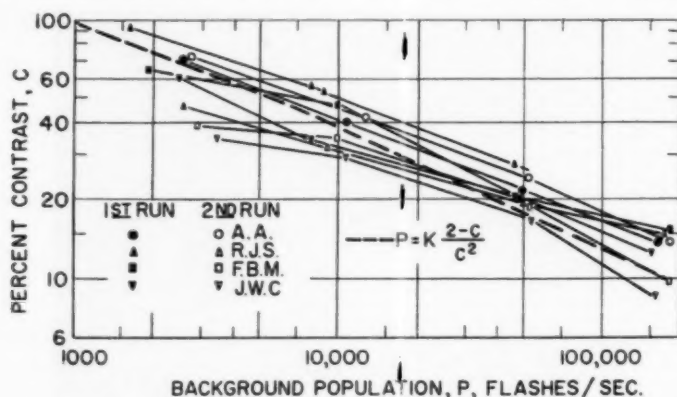


Fig. 7. Contrast required to discern a ten-line pattern as a function of the background population. The broken curve is derived from noise theory and is fitted at one point.

flashes per second may be obtained by dividing the indicated number by 0.2 second, the integrating time of the eye.

#### COMPUTATION OF THE SCINTILLATION LIMIT

The data of Figure 4 may be used together with Table I to determine the resolution limit of an ideal intensifier operating at any phantom thickness. An object contrast and a phantom thickness are chosen, *e.g.*, 35 per cent contrast at 18 cm. of presdwood. Table I shows that at 35 per cent contrast 12,500 quanta/sec. are required in order to perceive ten lines in a square. From Figure 4, we find 100,000 quanta/sec. are available in each square millimeter, whence we see that the limiting value of 12,500 represents population-wise the image of a square patch 0.125 sq. mm. in area, or 0.35 mm. on a side. Since this patch contains ten lines of the bar pattern, the limiting resolution is ten lines per 0.35 mm. or 28 lines/mm.

By this procedure, the contour plot of Figure 8 was obtained. The ultimate resolution in lines per millimeter of an ideal

tical radiography. Even though lowering of contrast has a pronounced effect, so that at 10 per cent contrast the corresponding value is 5 lines/mm., one is forced to the conclusion that the scintillation limit of resolution lies well beyond the limits set by more common shortcoming of fluoroscopic systems. For comparison of this ultimate limit with some more familiar examples, Figures 9 and 10 have been prepared.

Figure 9 shows the approximate resolution limit of various systems for a test object of 35 per cent contrast. Curve 1, for ordinary fluoroscopy, essentially represents the performance of the eye, since only at the higher brightness levels does the screen limit the resolution. With an early model of the Westinghouse image amplifier, the eye performance was raised to the level shown in Curve 2. Curve 3 is typical of good screen-film radiography. Curve 4 is the scintillation limit for an otherwise perfect system as taken from the preceding figure. These curves have been taken under conditions which do not per-

mit very exact intercomparisons. In particular, Curves 1 and 2 were taken by a single observer using screen mesh rather than a bar pattern, and the 35 per cent contrast figure is merely an estimate. Curve 3 was more accurately established with the use of a bar pattern and elimination of

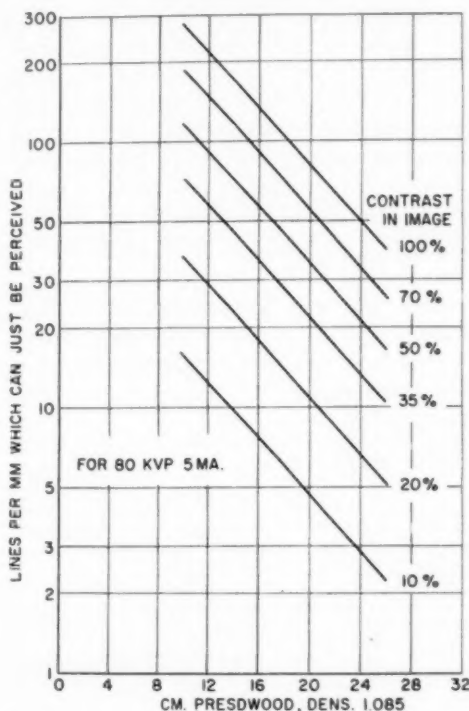


Fig. 8. Contours of scintillation-limited resolving power in fluoroscopy.

scattered radiation with a grid. The slight variation of resolution with phantom thickness is due to the finite focal spot size. The unsharpness due to this factor increases as the screen recedes from the object, which was kept at the center of the phantom.

Figure 10 gives a curve, replotted from Figure 8, of ultimate resolution versus object contrast for a fixed x-ray intensity. The intensity chosen was 50,000 quanta per square millimeter per second, which corresponds to a 21-cm. abdomen, with 80-kv., 5-ma. x-rays. On the same coordinates is plotted a curve taken from a

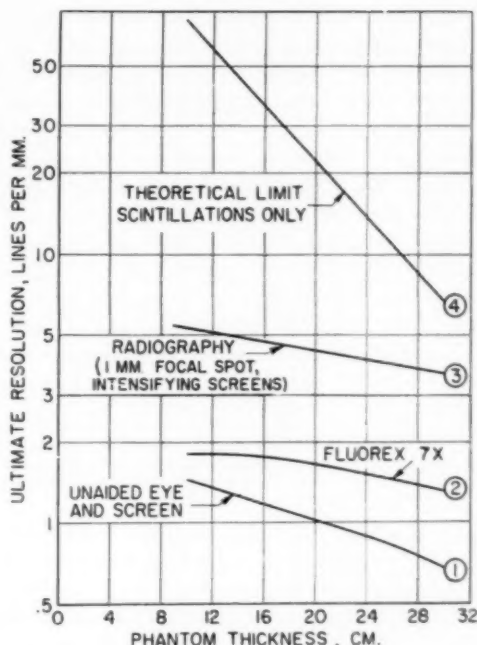


Fig. 9. Resolution limits for 35 per cent contrast test pattern.

paper by Van Allen and Morgan (8), which gives the corresponding relation between object contrast and resolving power for a typical film-screen combination. Here the resolution is determined primarily by the diffusion of light in the relatively thick intensifying screens. Comparison of the two curves makes it immediately evident that an intensifier which is limited in resolution only by the scintillation effect could outperform screen-film radiography by sizable factors.

In view of the relatively high values of resolving power which the scintillation limit permits, the early questions of what brightness gains would be useful no longer seem very significant. Since even at high brightness and contrast levels the eye cannot achieve resolving powers much over 12 lines per millimeter, it is evident that over a considerable range of conditions the eye limit will be reached before the scintillation limit, so that one would desire an amplification sufficient to bring the image to the brightness level for optimum critical



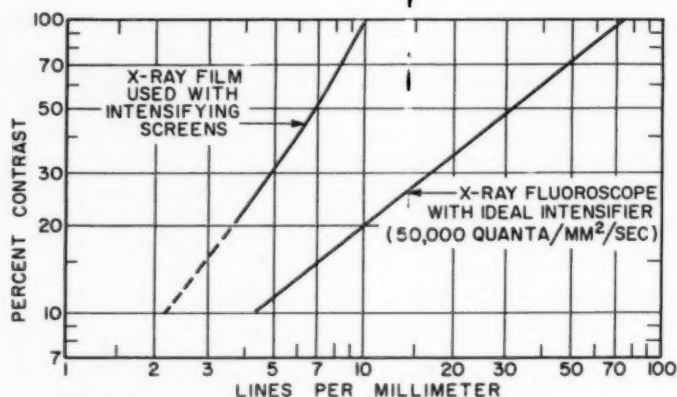


Fig. 10. Calculated limiting resolving power of an x-ray fluoroscope with an ideal image intensifier, operating under typical conditions of abdominal fluoroscopy. Shown for comparison is the resolving power of an x-ray film-screen combination, redrawn from Van Allen and Morgan's curve 5E (8).

viewing, say 30 millilamberts. Alternatively, geometrical magnification can be used for resolving fine detail.

It should be pointed out that much of the matter of interest in medical fluoroscopy is of low contrast, where the scintillations may limit to a degree the resolving power. Thus one cannot ignore altogether the effect, and some precautions must be taken to preserve and utilize a reasonable fraction of the number of quanta which the patient dose permits. It does seem, however, that the factors inimical to high resolving power in image amplifying devices consists of the familiar faults of thick fluorescent screens, finite focal spots, and scattering in the subject. Other faults which may accompany the amplifying device itself, such as electron-optical deficiencies, lens aberrations and, in television type systems, camera tube noise, must also be dealt with. These problems appear, however, to be technological rather than fundamental in nature, and it seems certain that once they are overcome, electronic

fluoroscopy will be capable of resolving powers well in excess of those which are accepted as satisfactory in present-day screen-film radiography.

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Westinghouse Electric Corporation  
East Pittsburgh, Penna.

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#### SUMARIO

##### El Límite del Centelleo en la Roentgenoscopia

Hízose una determinación de la facultad resolutive final en la roentgenoscopia con intensificador de imágenes cuando no la limitan más que los efectos de los cuántums.

El problema se resuelve en dos partes: primera, determinación del número de cuántums importantes obtenibles en la pantalla en varias condiciones fluoroscópicas.

picas; segunda, determinación de la capacidad del ojo para integrar un cuadro centelleante en un patrón significativo. Con esos datos, cabe predecir la acción de un intensificador ideal de imágenes para toda la escala de condiciones fluoroscópicas.

Se averiguó el número de cuántums obtenibles por medio de un cuentachispas, usando un cristal de yoduro de sodio y un fotomultiplicador 5819. Se determinó la capacidad del ojo para distinguir un patrón formado de chispas lanzadas al azar, con la ayuda de un quinescopio de televisión sobre el cual se desplegó un patrón de barra delineado por puntos brillantes derivados de un foco de rayos X. Con los

datos así obtenidos, fué posible determinar, en líneas por milímetro, el límite de resolución de un roentgenoscopio intensificador ideal funcionando con cualquier espesor fantasma.

Los límites de las facultades de resolución resultaron sorprendentes por lo altas; hasta en el abdomen superan las de la radiografía práctica con películas y pantalla. A la luz de esos valores relativamente altos, dejan de parecer muy importantes las cuestiones anteriores de qué aumentos de la brillantez serían útiles. Se necesitarán tanto brillantez elevada como aumento lineal para capacitar al ojo para recoger toda la información accesible en la imagen roentgenológica.



# EDITORIAL

## The Radiation Hazards of Diagnostic Procedures

Recent articles dealing with radiobiologic research and a rather extensive bibliography on the hazards of exposure to patient and personnel alike, during diagnostic fluoroscopy and radiography, have stimulated a good deal of sober thought and discussion both among radiologists and in associated clinical specialties. From some of the opinions expressed, there seems to be an implication that the radiologic fraternity has not given sufficient thought and attention to this problem, when indeed most of us in radiology will agree that the hazards have been appreciated for many years.

It is true that some have not been as conscious of this danger as others (1, 2). Many of us have learned the hard way. We all recall the days when it was considered quite legitimate to give pelvic irradiation in the treatment of various benign forms of uterine bleeding, some purely functional and some on an organic basis. The bad results following some of these procedures are well known and have brought a feeling of shame or even guilt to many a radiologist who was attempting to help out in one pelvic disorder or another. Often it was found that gravid uteri had been heavily irradiated, with the eventual delivery of a monstrosity. There were frequent mistakes in judgment in differentiating between benign and malignant processes. Fortunately for us, we have profited from these past experiences and have come to know that the effect of a so-called "stimulating dose" is always a reaction to injury and that the term "stimulating" should be considered a myth. With the exception of certain benign skin lesions, it has been generally conceded that ionizing radiations should be reserved for malignant conditions. As a

general rule, they have no place in the treatment of a benign process. Moreover, it is fortunate that improved surgery has eliminated the necessity for the employment of pelvic irradiation for other than malignant disease. Consequently, one can make the generalization that, aside from a few die-hards, the whole radiologic fraternity *does* appreciate the diagnostic difficulties and the dangers involved.

It was not until after the recent impetus given to research in this problem following the widespread use of isotopes and the report of the Atomic Bomb Casualty Commission that the real dangers were generally appreciated by our confreres in related specialties, in spite of the fact that the radiologists have been acutely aware of the necessity for caution and protective measures for some time. In support of the radiologist, it can be said that the martyrs and pioneer workers of the early part of the twentieth century soon taught a respect for the new modality that they were using—both gamma and roentgen radiation—and were quick to pass on to their pupils the realization of need for caution. As far back as the late twenties, P. M. Hickey, at that time Professor of Radiology at the University of Michigan, was inquiring by questionnaire into the possible harmful genetic effects among the progeny of radiologists in much the same manner as Macht and Lawrence have recently done (9). Hickey's data, I believe, were never published.

I believe that every radiologist's rule has been and should still be that *any amount of radiation to either patient or personnel which is not necessary should always be considered too much.*

In Chamberlain's recent article on "Radiation Protection" (3), he emphasizes this

last fact over and again. For example, he speaks about the "maximum permissible exposures" that have been agreed upon internationally, but further emphasizes that these do not limit "the use of higher levels of exposure for good and sufficient cause," and "that the least possible exposure should not fail to be the goal at all times." "It is still necessary to apply interpretation of the degree of need for a particular radiation exposure as well as considerable skill in the measurement of the physical factors that will deliver it." In other words, common sense should govern our every move.

I am constantly impressing upon my students and clinical associates the need for caution, but in spite of this I still have to argue at times with clinicians about curtailing this or that examination because of the existence of pregnancy or too frequent repetition of any routine type of examination.

We mention all these things because we think it is important for our confreres both in the field of biologic research and in other fields of medicine to know that we radiologists have been cognizant of these dangers. This did not begin with the first atomic explosion. As a matter of fact, the "atomic era" might better date back to the time of discovery of x-rays and radioactivity, before the turn of the century.

A recent excellent editorial in the *Journal of the American Medical Association*, entitled "X-rays During Pregnancy" (4), discusses injury to the developing fetus and calls attention to the problems of the production of gene mutations and the whole question of genetic effects in animals and of whole-body radiation injury. Because very little is known about the exact amount of ionizing radiation dosage required to produce genetic effects and, by the same token, the difficulty of interpreting this in terms of human genetics, we really are still much in the dark as to the specific amount necessary to produce the effects in man; yet the Russells (2, 8) have shown that there is good reason

to believe from their observations that the rate of induction of mutations is higher per locus in the laboratory mammal than in *Drosophila*. This difference would be cause for greater caution in the use of irradiation in man than had been indicated by the work on the fruit fly alone. The mechanisms of heredity, moreover, are perhaps much the same for man as for the insect. Thus far, we have no proof to the contrary. The mere fact that there have been cases recorded where normal offspring were born from mothers who had received considerable x-radiation is not a good argument against the fact that irradiation does harm, since it may be necessary to follow several generations before genetic defects become apparent. We can only stick to the rule that any amount of irradiation unnecessarily given is too much, and wait for the results of further research.

It is of interest to note the divergence of findings in regard to the amount of x-radiation delivered during fluoroscopy. This divergence is borne out by Weens, Clements, and Tolan (5), Ritter, Warren, and Pendergrass (6), and others. Further comparative statistics would be advisable in this regard.

Concerning the dangers of radiography, the pelvimetric and pelvioradiographic procedures are always brought up as the worst offenders. This might be justified were it not for the fact that now any need for examination, except very close to term, is unnecessary. The examination should never be done during the first trimester of pregnancy, but always near term. There is actually no need to do it at any other time. It is well, however, to call attention to the fact that even during a long series of pelvioradiographic studies (over 2,000), about one-third of which were done in the first trimester (7), there occurred not one single case of accidental monstrosity. The radiation dosage for a routine pelvimetric and pelvioradiographic examination as determined in the Radiology Department of Jefferson Hospital, where a good deal of this work is done, has been

shown to be surprisingly low. With improvement in technic, we have been able to decrease the total irradiation. It now stands at a maximum of 4 r delivered into the mid-pelvic structures in a rather heavy patient.

We are by no means minimizing the suggestion of Russell and Russell (8) that, where possible, the examination of any female abdomen should be limited to the two weeks following a normal menstrual period, but whether that would be practical in all cases is problematic. Let the necessity of the moment dictate in every case. It has always seemed to me that if we are to regard pelvimetry as particularly dangerous, then there is very little excuse for irradiating the abdomen of any person during the period of fertility. As Dr. Ramsay Spillman of New York has so often emphasized, it is as important to protect the gonads of the male as of the female. He has told me that he always protects the gonads of the male in any type of abdominal examination.

It may be that we will find, many generations hence, that the use of any irradiation at all, for any purpose, during the period of fertility was unwise and will have done irreparable damage to the human race. In the meantime, we should get away from the term "safe dosage" to one of "maximum permissible exposure" or, let us say, one which by the requirements of the moment seems justified.

Chamberlain (3) has spoken of methods of good practice in controlling the radiation hazard, and we recommend his article, which we have previously quoted. We should always ask ourselves in any type of radiographic examination, either fluoroscopic or radiographic, and in every case of therapeutic application, the old

question, "Is this trip necessary?" We will then get ourselves in no trouble. The hazard of radiation, particularly to embryonic tissue has always been there and will continue to be. Safe dosages are not yet fully established in spite of the fact that we know that the natural radiation sources combine to produce about one-twentieth of the now maximum permissible level for those working with ionizing radiations. Whether the gonads of the fetus can withstand as much as 1 r of radiation exposure during pelvimetric examination will not be known for several generations, if ever. In the meantime, it behooves us to adopt a sane but not necessarily an overly apprehensive attitude about all roentgen exposure. We must never relax in being cautious in applying ionizing radiation to any patient at any time, but particularly during the period of fertility and more specifically to women before the menopause.

PAUL C. SWENSON, M.D.

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## ANNOUNCEMENTS AND BOOK REVIEWS

### MAINE RADIOLOGICAL SOCIETY

At a recent meeting of the Maine Radiological Society, the following officers were elected for 1954-55: President, Clark F. Miller, M.D., Lewiston; Vice-President, G. E. Clifford Logan, M.D., Portland; Secretary-Treasurer, Walter A. Russell, M.D., 6 E. Chestnut St., Augusta. The Society meets four times a year, in June, October, December, and April.

### KANSAS RADIOLOGICAL SOCIETY

The Annual Postgraduate Course in Radiology, in conjunction with the Annual Meeting of the Kansas Radiological Society and the Radiological Society of Greater Kansas City, will be held Feb. 14-17, 1955, at the University of Kansas Medical Center, Kansas City, Kans. The first two days will be devoted to roentgen diagnosis, the third to radiation therapy, and the fourth to the discussion of radioactive isotopes as used in diagnosis and therapy.

Guest speakers include Lauren V. Ackerman, M.D., William H. Beierwaltes, M.D., Carl C. Birkelo, M.D., James W. J. Carpender, M.D., Carl L. Gillies, M.D., Philip J. Hodes, M.D., John F. Holt, M.D., Bertram V. A. Low-Beer, M.D., and James Stober, Physicist. Special features of the course are a tumor clinic, a film reading session, and a round table conference with most of the guest instructors participating.

For further information address: G. M. Tice, M.D., Chairman, Department of Radiology, University of Kansas School of Medicine, Kansas City 12, Kans.

### NEW ENGLAND ROENTGEN RAY SOCIETY

The Eastern Conference of Radiologists will hold its Annual Meeting March 3, 4, and 5, 1955, in the Sheraton-Plaza Hotel, Boston. The New England Roentgen Ray Society, as host, warmly invites the attendance of all radiologists and their guests. A program for Friday and Saturday morning, stressing newer concepts in diagnosis and therapy, is being arranged. A banquet will be held on Friday night. For additional information, address Stanley M. Wyman, M.D., Secretary, New England Roentgen Ray Society, Massachusetts General Hospital, Boston, Mass.

### ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

At the annual meeting of the Rocky Mountain Radiological Society held in Denver, Colo., Aug. 12-21, 1954, the following officers were elected: President, Alfred M. Popma, M.D., Boise, Idaho; President-Elect, Maurice D. Frazer, M.D., Lincoln,

Nebr.; 1st Vice-President, Thomas J. Kennedy, M.D., Denver; 2nd Vice-President, Charles F. Ingersoll, M.D., Denver; Secretary-Treasurer, John H. Freed, M.D., 4200 E. 9th Ave., Denver 20; Historian, John S. Bouslog, M.D., Denver; Councilor to the American College of Radiology, Robert D. Moreton, M.D., Fort Worth, Texas. Members of the Executive Committee are Edward M. Hayden, M.D., Tucson, Ariz.; Gerald S. Maresh, M.D., Denver, Colo.; Angus K. Wilson, M.D., Salt Lake City, Utah.

### DR. WENDELL G. SCOTT HONORED

Dr. Wendell G. Scott, of St. Louis, was recently awarded the degree of Doctor of Science by the University of Colorado, Boulder, Colo.

### OAK RIDGE INSTITUTE OF NUCLEAR STUDIES

Applications for U. S. Atomic Energy Commission *Fellowships in Radiological Physics and Industrial Hygiene* for the 1955-56 school year are now being received by the Oak Ridge Institute of Nuclear Studies.

The industrial hygiene fellowship program supports individuals who are studying for the master's degree in this field at either the Harvard University School of Public Health or the University of Pittsburgh Graduate School of Public Health. Radiological physics fellowships are carried out in three separate programs as follows: at Vanderbilt University and Oak Ridge National Laboratory, at the University of Rochester and Brookhaven National Laboratory, and at the University of Washington and the Hanford Works. In each case, nine months of course work at the University is followed by three months of additional study and field training at the co-operating Atomic Energy Commission installation.

University faculty members are invited to apply for places in the *Oak Ridge Research Participation Program* carried out by Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies. Through this program, faculty members may conduct research in Oak Ridge for periods of three months to a year.

Oak Ridge National Laboratory is the principal center of research, although limited opportunities for participation also exist at the University of Tennessee-Atomic Energy Commission Agricultural Research Program and the Medical and Special Training Divisions of the Institute.

Opportunities are offered for fundamental and applied research in physics, chemistry, metallurgy, biology, mathematics, and engineering, with a number of nuclear reactors and particle accelerators as the

principal research instruments. The University of Tennessee program is concerned with the internal and external effects of radiation on farm animals. The Medical Division conducts extensive studies of the internal and external uses of radioisotopes in cancer treatment, and studies in radiation physics. In the Special Training Division are opportunities for research in instrumentation, radioisotope applications, and the occurrence of radioactivity in ores and sea water.

Additional information on all these projects may be obtained from the University Relations Division, Oak Ridge Institute of Nuclear Studies, P.O. Box 117, Oak Ridge, Tennessee.

## In Memoriam

SIDNEY A. PORTIS, M.D.

1894-1954

Dr. Sidney A. Portis, a member of the Radiological Society of North America since 1921, died in Baltimore on May 24. Dr. Portis was born in 1894. He received his B.S. degree from the University of Chicago in 1916, was graduated from Rush Medical College in 1918, and served his internship in Cook County Hospital.

Dr. Portis was certified by the American Board of Internal Medicine, in Gastroenterology, in 1937, and his chief interest was always in that field. He was associated in the course of his active career with Rush Medical College, Loyola University, and Cook County, Mercy, and Michael Reese Hospitals, Chicago. He had recently left Chicago to make his home in California. He was a Fellow of the American College of Physicians and a member, among other organizations, of the Gastroenterological Association of North America, the American Gastroenterological Association, and the Chicago Roentgen Society.

## Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

**HERZKRANKHEITEN IM SÄUGLINGESALTER.** By PRIV. DOZ. DR. ETTORRE ROSSI, Zurich. Foreword by Prof. Dr. Guido Fanconi, Zurich. A book of 374 pages, with 198 illustrations and 14 tables. Published by Georg Thieme, Stuttgart, 1954. Distributed in the United States and Canada by the Intercontinental Medical Book Corp., 381 Fourth Ave., N. Y., 1954. Price DM 65.—(\$15.45)

**KLINISCHE FEHLDIAGNOSEN.** By PROF. DR. M. BÜRGER, Direktor der med. Universitätsklinik, Leipzig. Second edition. A volume of 550 pages,

with 214 illustrations and 55 tables. Published by Georg Thieme, Stuttgart, 1954. Distributed in the United States and Canada by the Intercontinental Medical Book Corp., 381 Fourth Ave., N. Y., 1954. Price DM 59.40 (\$14.15)

**STRAHLENDOSIS UND STRAHLENWIRKUNG. TAFELN UND ERLÄUTERUNGEN. UNTERLAGEN FÜR DEN STRAHLENSCHUTZ.** By B. RAJEWSKY, with the collaboration of K. AURAND, O. HUG, H. MERGLER, H. MUTH, H. PAULY, A. SCHRAUB, E. SIX, I. WOLF, Max-Planck-Institut für Biophysik, Frankfurt a. M. A monograph of 280 pages, including numerous graphs and tables. Published by Georg Thieme, Stuttgart. Distributed in the United States and Canada by Intercontinental Medical Book Corp., 381 Fourth Ave., N. Y., 1954. Price DM 11.—(\$2.65)

**DIAGNOSTICA RADIOLOGICA E TERAPIA FISICA IN ODONTOIATRIA.** By GIOVANNI SMERCHINICH, già insegnante di radiologia nella Scuola di specializzazione in odontoiatria dell' Università di Milano. A monograph of 330 pages, with 760 illustrations. Published by Ulrico Hoepli, Milan, 1954. Price Lire 3,500.

## Book Reviews

**DIE HALSWIRBELSÄULE. PATHOLOGIE UND KLINIK.** By DR. MED. GERHARD EXNER, Privatdozent für Orthopädie an der Universität Marburg/Lahn. With a Foreword by PROF. DR. H. C. GEORG HOHMANN, München. A monograph of 140 pages, with 42 illustrations. Published by Georg Thieme, Verlag, Stuttgart, 1954. Distributed in the United States and Canada by the Intercontinental Medical Book Corporation, New York. Price \$5.15.

This study of the cervical spine opens with an account of anatomy and function and a discussion of the clinical and roentgen examination. The major part of the book is devoted to the degenerative and osteochondritic changes of the cervical spine, particularly in its lower area. The author supports the modern concept that most of the changes formerly called neuritic, such as brachial plexus neuritis, occipital neuritis, etc., are caused by pressure upon the nerve roots due to disk lesions or degenerative changes. In an interesting animal experiment it was shown that, when the nuchal muscles in rats are cut, an excessive load is thrown upon the lower cervical spine. Within six months degenerative changes and disk lesions develop and the microscopic section will show pressure necrosis of nerve cells in the intervertebral ganglion, with connective-tissue replacement. Microscopic studies were also made of the lower cervical spine and of the structures of the right shoulder joint, postmortem.

in patients with lower cervical spine lesions. The author believes that bursitis calcarea of the shoulder is due to misdirection of the calcium metabolism on the basis of trophic or neurovegetative disturbances in the lower cervical spine.

The therapy of the cervical syndrome is well discussed. Novocain blocking of the stellate ganglion is described in detail.

Injuries and acute and chronic inflammatory changes in the cervical spine are dealt with only briefly.

The author presents many novel ideas. One might not fully agree when he links Bell's palsy and angina pectoris with disk disease in the lower cervical spine, but his line of reasoning appears logical and his style is interesting and readable.

#### AMERICAN COLLEGE OF RADIOLOGY

The annual meeting of the American College of Radiology will be held in Chicago at the Drake Hotel, Feb. 9-12, 1955.

The Board of Chancellors will meet Wednesday and Thursday, Feb. 9-10.

On Friday, Feb. 11, the Annual Meeting and banquet, preceded by the College Convocation, will be held.

The 22nd Annual Conference of Teachers of Clinical Radiology will be held Saturday, Feb. 12.

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## ROENTGEN DIAGNOSIS

### THE HEAD AND NECK

**Premature Synostosis of the Cranial Sutures: A Review.** Frederic N. Silverman. Ohio State M. J. 50: 131-137, February 1954.

This paper is concerned with the roentgen recognition of the usual varieties of premature synostosis of the cranial sutures and the criteria for identifying those patients who may benefit by surgical intervention as well as those for whom surgery has nothing to offer.

In premature synostosis the brain continues to grow normally but cranial growth is halted along the closed suture or sutures. Compensatory changes result in an abnormally shaped skull unless all the sutures are involved. If the sagittal suture closes, lateral growth is stopped and the head becomes narrow, elongated, and high. If the coronal suture closes, the anteroposterior diameter of the head will be short and the skull broad and high. If all the sutures are prematurely fused, a true condition of microcrania exists, the brain, which has its greatest increase in size during the first year of life, is completely hemmed in on all sides, and compensatory growth of the skull into an abnormal shape is not permitted. The intracranial pressure rises rapidly as the normal processes of cerebral growth attempt to proceed in the rigid bony case, and adverse effects on the brain may be expected early.

Throughout childhood at least, the sutures are clearly defined radiologically and roentgen examination will reveal abnormalities in closure. With synostosis of all the sutures, the clinical appearance does not differ from that of microcephalic microcrania, and in early infancy the behavior of the children may not be significantly different. Roentgen examination, however, will be conclusive in ruling out the latter condition, for which surgery has nothing to offer. In the microcrania due to prematurely closed sutures the bones are thinned, and craniolacuna-like areas of softening may be observed. If the primary defect is in the brain, roentgen examination may demonstrate normal sutures; if the sutures are closed, there are no signs of increased intracranial pressure, the bones may be thicker than normal, and pneumatization of the temporal bones may be exaggerated.

Seven roentgenograms; 4 photographs; 1 drawing.

ZAC F. ENDRESS, M.D.  
Pontiac, Mich.

**Gargoylism. Report of a Case.** N. W. Nisbet and Barbara F. Cupit. Brit. J. Surg. 41: 404-412, January 1954.

The trend of opinion places gargoylism in the group of metabolic diseases distinguished by the abnormal storage of products of metabolism, comparable with the lipoidoses (Gaucher's disease, Niemann-Pick's disease, Schüller-Christian's disease and amaurotic juvenile familial idiocy) and having features in common with them. In the case of gargoylism the abnormal material is a carbohydrate, possibly a glycoprotein, although this has not been definitely proved.

This paper presents a very detailed case report of a patient who was observed from time to time, from birth to death at six years of age. It is an excellent description of the pathological and physical changes present in this disease and of the radiologic findings.

The illustrations include numerous photographs of the pathological specimens, excellent roentgenograms, and photomicrographs. WYNTON H. CARROLL, M.D.  
Shreveport, La.

**Diagnosis and Early Treatment of Lesser Facial Fractures.** Gerson Lowenthal. Ann. Otol., Rhin. & Laryng. 62: 995-1034, December 1953.

The authors discuss the diagnosis and treatment of fractures of the face, excluding those with intracranial or occlusal involvement. Only the roentgen aspects are considered in this abstract.

Roentgen studies are essential for the diagnosis and planning of treatment in facial injuries and are of medicolegal importance. Roentgenography of the head is, however, difficult, particularly in children. Superimposition of bony structures may render interpretation of the films unsatisfactory, and fractures demonstrable by physical examination may not be visible on the roentgenogram. In the zygomatic area, roentgenographic findings are reliable with respect to both the presence and absence of fracture. In the nasal pyramid area, positive evidence of fracture is conclusive, although negative roentgenograms may not be.

The *Waters' view* (postero-anterior nose-chin) reveals the antra, orbital borders, frontal sinuses, zygomatic arches, nasal septum, and lateral walls of the bony pyramid. Changes in the transverse diameter of the orbits are almost pathognomonic of orbital fractures. Other findings indicative of fracture are clouding of the antrum, asymmetry of the zygomatic arches, and deviations of the nasal pyramid or septum.

A *lateral view* (soft-tissue nose) should be obtained in all suspected cases of nasal pyramid fracture. Taken with the injured side toward the film, it will visualize depressed fractures of the nasal dorsum, tip fractures of the nasal bones, and some linear fractures. It does not reveal lateral displacement.

The *occlusal view* (axial of the nose) may reveal lateral deviations of the nasal pyramid and anterior nasal spine. Though often unsatisfactory, this view should be attempted to supplement the Waters' view of nasal fractures.

A *modified Waters' view* or extended Waters' view, taken with the nose elevated more than in the conventional position, is useful in zygomatic fractures.

The *submentovertical (basal) view* is useful in demonstrating fractures of the zygomatic arch and the anterior surface of the maxilla. The individual arch may be better visualized with the head turned slightly, usually to the contralateral side.

The *Caldwell view* (nose-forehead) reveals the frontal sinuses and is useful in the study of the ethmoid region.

With the development of a new compact hand stereoscope, greater usefulness is available for stereoscopic Waters' and lateral views of the skull in the study of facial fractures.

In facial injuries, studies of the cervical vertebrae should be made as a precaution when symptoms cannot readily be explained in terms of known injuries. Several investigators have reported fractures of the cervical spine resulting from injuries of the "whiplash" type.

Six roentgenograms; 20 photographs; 2 tables.

A. J. NICHOLAS, M.D.  
Shreveport, La.

**Dacrocystography. I. The Normal Lacrimal Apparatus.** Benjamin Milder and Byron H. Demorest. *Arch. Ophthalm.* 51: 180-195, February 1954.

The authors present a simple technic for dacrocystography, with ethyl iodophenylundecylate (Pantopaque) as the contrast medium. From a study of 30 patients, details of a normal dacrocystogram were constructed. The forehead-nose (Caldwell) and lateral projections were used to visualize the nasolacrimal tract.

Bilateral studies are desirable for evaluation and comparison of the function of the two drainage systems. In such studies, an oblique view is substituted for the lateral of the second eye.

The pattern of the medium in the drainage system, as indicated by a composite drawing of the normal roentgenograms, follows closely the usual description of the gross anatomy of this structure. Complete filling of the drainage system is not necessary. The emptying time, demonstrated on a 30-inch follow-up film, provides the most valuable information regarding the function of the system; evidence of more than traces of the medium on this film indicates abnormal drainage function.

The ophthalmologist should study the dacrocystograms personally to form a clinical impression as a basis for treatment.

Thirteen roentgenograms; 1 photograph; 3 drawings.

**Importance of Certain Consonants in Esophageal Voice After Laryngectomy.** Annie Moolenaar-Bijl. *Ann. Otol., Rhin. & Laryng.* 62: 979-989, December 1953.

Speech therapy of laryngectomized patients should be started as soon as possible after operation. Of 36 patients operated upon in the Groningen University Clinic (Netherlands), 30 obtained reasonable to very good (pharyngeal-) esophageal speech; 3 have a little voice but not sufficient for conversation; 3 have continued to make shift with buccal whisper.

Roentgen studies were of interest in demonstrating the mechanisms of extra-laryngeal voice production and in showing the relation between consonant formation or the intake of air into the esophagus. These studies showed a filling up of the esophagus during the pronunciation of "mah", "pah", and "p" and indicated the advantage of beginning speech training with these sounds.

Eight roentgenograms; 4 curves.

A. J. NICHOLAS, M.D.  
Shreveport, La.

## THE CHEST

**Bronchography.** J. Antrim Crellin, J. Stauffer Lehman, and Michael P. Brignola. *Dis. of Chest* 25: 184-192, February 1954.

The authors emphasize the importance of accurate localization of bronchial disease as a prerequisite to proper surgical extirpation of affected pulmonary segments. Bronchography provides a means not previously available for the accurate diagnosis of many bronchial lesions and has unquestionably stimulated interest in the diagnosis of bronchopulmonary suppurative disease.

The aim in all bronchography is complete five-lobe bronchial mapping. The authors prefer the transnasal endobronchial catheter method. Preliminary to bron-

chography, several daily measurements of sputum are recorded. If the amount is more than 45 c.c. in twenty-four hours, postural drainage is instituted and antibiotics are administered. Cocaine, 10 per cent solution, is used for topical anesthesia. For children, general anesthesia is necessary. Ideally, one lung is examined at a single sitting, and the other mapped after an interval of three weeks. This allows time for clearing of the first lung. Bilateral bronchography at a single sitting can be performed if a prompt diagnosis is urgent, or if an economic factor enters. During the entire bronchographic procedure, constant check of the flow and distribution of the iodized oil is obtained by intermittent fluoroscopic observation. Spot or flash films are obtained as deemed necessary.

The authors describe their preparation of the patient, premedication, fluoroscopic observations, and positions desired.

Six roentgenograms. HENRY K. TAYLOR, M.D.  
New York, N. Y.

**Significance of Bronchography for the Therapy of Pulmonary Tuberculosis.** P. Thurn. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 198-208, February 1954. (In German)

For selective and routine bronchography the author has used an aqueous solution of iodine with streptomycin protection. In a series of over 100 bronchographies he encountered no complications or spread of an active tuberculous lesion, although in the majority of cases the sputum was positive for acid-fast organisms.

Bronchography is necessary to explain the source of a positive sputum when roentgenographic and bronchoscopic findings are inconclusive. It is sometimes the only method for differentiating between areas of infiltration and atelectasis and for excluding endobronchial changes in the remaining lobe or lobes prior to lobectomy or segmental resection.

The author discusses and illustrates 13 cases in which selective and routine bronchography was helpful in the recognition of bronchiectases and bronchostenoses and in reaching a decision as to whether chemotherapy, collapse, thoracoplasty, resection, lobectomy, or pneumonectomy should be done.

In acute active tuberculous disease periodic bronchography is necessary to check the result of chemotherapy since, if a bronchostenosis should develop, a surgical approach could be decided on without undue delay.

When bronchography reveals stenosis or closure of bronchi, pneumothorax therapy is contraindicated because of the danger of possible permanent atelectasis and perforation of cavities into the pleural cavity, with resulting empyema and bronchopleural fistula. In shrinking lesions with bronchostenosis, pulmonary resection is indicated instead of thoracoplasty.

Fourteen roentgenograms. E. KRAFT, M.D.  
Newington, Conn.

**Experiences with Planography.** B. Pollak. *Dis. of Chest* 24: 663-669, December 1953.

The author has found planigraphy advantageous for examinations of the chest in the vertical position. The center of the suspected lesion is determined at fluoroscopy and marked with skin pencil on the chest. A scout film is then taken, and one planigram in the layer in which the lesion is suspected. These are developed

to check the exact position of the patient and exposure technic before further planigrams are obtained.

Planigraphy is indicated on all patients where a more detailed analysis of pathological changes demonstrated on plain films is desired. It is especially useful in pulmonary tuberculosis, showing the exact location of cavities, the condition of the cavity wall, and often the draining bronchus. It has also been found of assistance in serial re-examinations to evaluate the effectiveness of treatment and in the early recognition of progressive or retrogressive changes even in minimal lesions.

Eight roentgenograms; 2 photographs.

FRANK T. MORAN, M.D.  
Auburn, N. Y.

**Congenital Multiple Cysts of the Lung.** Hermann Lichtenstein. *Dis. of Chest* 24: 646-654, December 1953.

A mass radiographic survey of immigrants to Israel revealed 188 with lung cysts of various types in a period of one year. Ninety-two had congenital multiple cysts, 62 males and 30 females. In this group there were no spontaneous complaints. Thirty reported no previous symptoms. Thirty-eight complained mostly of cough, associated in 26 cases with purulent, bad-smelling sputum. Three had had hemorrhages, and 5 toxic signs, such as fever and weakness. In the remainder an earlier history was not available.

Roentgenograms showed the disease as a set of circular shadows with thin contours, sometimes approximately equal, sometimes of different diameters. In the majority of cases the shadows covered a whole lobe. In the presence of infection the entire appearance may be changed roentgenographically, with blurring of the cystic pattern.

The term "cystic disease" as generally used does not refer to a definite entity, but includes a number of forms. The author emphasizes the importance of a precise diagnosis of the different varieties. In his series the congenital origin of the cysts was supported by the following observations: (1) The majority of the patients were in the younger age groups. (2) There were many cases with no signs of secondary infection. (3) There was no indication of an earlier pathologic process which might have been responsible for the cysts. (4) There was a high incidence among persons from certain areas, suggesting a possible hereditary origin.

Although antibiotic treatment has symptomatic value, the only specific therapy is excision of the affected lobe. Extreme attitudes should be avoided, however, and each case judged on its merits. In the case of an aged person with clinical signs of infection, conservative antibiotic therapy should be tried; in a young person there should be no hesitation in recommending surgery.

Ten roentgenograms; 1 table.

FRANK T. MORAN, M.D.  
Auburn, N. Y.

**Localized Pulmonary Hypertrophic Emphysema.** William Henry. *J. Thoracic Surg.* 27: 197-203, February 1954.

The author reports a case of localized pulmonary hypertrophic emphysema in a ten-year-old boy. A chest film made soon after the patient had recovered from a respiratory infection showed marked emphysema of the right lung. A non-opaque foreign body was sus-

pected, but bronchoscopy was negative. Subsequent Lipiodol bronchograms showed a large air-filled cystic area in the posterolateral lung field.

At operation, three separate areas of pulmonary emphysema, involving the posterior segment of the right upper lobe, the superior segment of the right lower lobe, and the lateral basal segment of the right lower lobe, were found. The normal lung was compressed by the emphysematous areas, which were removed by segmental resection. The bronchi, arteries, and veins were smaller than one would expect in a normal lung segment.

The etiology of this condition is obscure. The author feels that it is probably congenital in origin. It should not be confused with regional obstructive emphysema from thick viscid mucus or from aspiration of non-opaque foreign bodies. Valve-like mucosal folds, compression by an adjacent pulmonary vessel, and localized bronchial chondromalacia have all been described as underlying causes. This is the tenth recorded case of the disease occurring in infancy or childhood; 2 examples have been reported in adults.

Bronchoscopy and the Lipiodol bronchogram were of great assistance in determining the extent of involvement and the need for thoracotomy. Surgical excision appears to be indicated in this condition.

Five roentgenograms; 1 photograph; 1 photomicrograph; 1 drawing.  
RENE FORCIER, M.D.  
St. Paul, Minn.

**A Case of Progressive Bilateral Bullous Emphysema Complicated by Pneumothorax.** Howard H. Englander. *Ohio State M. J.* 50: 128-130, February 1954.

The author reports a single case of progressive bilateral bullous emphysema (see Price and Teplick. *Arch. Int. Med.* 77: 132, 1946) in a Negro male of forty-five, complicated by a left-sided spontaneous pneumothorax. Treatment included aspiration and drainage, and follow-up roentgenograms showed a gradual re-expansion of the left lung, though the emphysema persisted.

The clinical features of progressive bilateral bullous emphysema are not distinctive and diagnosis is dependent upon roentgenography, which shows bullae replacing normal lung markings in the upper lung fields with a patternless tracery of fine linear shadows. Confluence of some bullae and discreteness of others cause great irregularity of size and shape. The lower lung fields show interstitial fibrosis, and the thorax appears lengthened because of the depressed diaphragm.

The case reported here is believed to be the first complicated by pneumothorax.

Three roentgenograms. ZAC F. ENDRESS, M.D.  
Pontiac, Mich.

**Infected Emphysematous Bullae. Report of Five Cases.** Emil Rothstein. *Am. Rev. Tuberc.* 69: 287-296, February 1954.

Emphysematous bullae are relatively common and usually occur at the apex, base, or mediastinal free border of the lung in middle-aged males. Five cases of infected bullae are reported; 3 of these were tuberculous infections. On the basis of roentgenographic and clinical findings, the author feels that this syndrome can be differentiated from lung abscess and pulmonary tuberculosis with cavitation.



A generally benign clinical picture is the rule. Helpful roentgen findings are the presence of obvious bullae elsewhere, the rapid appearance of fluid levels and apparent extensive cavitation after only a few days illness. Involvement of the surrounding lung is relatively slight, and pleural involvement is slight or absent. In addition, an infected cyst usually communicates freely with a bronchus, while a bulla is difficult to fill on bronchography because of the indirect communication with the bronchial tree. In all of the cases reported, the infection resolved, with resultant obliteration of the bullae.

Fifteen roentgenograms; 1 photograph.

JOHN H. JUHL, M.D.  
Minneapolis, Minn.

**Roentgen Studies in Suppurative Pneumonia of Infants and Children.** John A. Campbell, David C. Gastineau, and Frank Velios. *J.A.M.A.* 154: 468-472, Feb. 6, 1954.

Acute suppurative pneumonias with their relatively high mortality constitute a problem of major importance to the pediatrician. The infecting organisms invade the bronchial walls, peribronchial tissues, and interstitial structures as well as the alveoli, reducing vital capacity through consolidation. Because of the bronchogenous spread, different roentgen stages of involvement are seen simultaneously, with changes disappearing in one lobe while they are developing in another.

An unequivocal diagnosis of suppurative bronchopneumonia is probably never justified on roentgen examination alone. Nevertheless, in most instances the roentgen studies show a sufficiently high order of specificity to provide an early recognition of this type of disease. Roentgenograms taken at judiciously spaced intervals serve as an invaluable guide for therapy by disclosing the type and extent of the pleuropulmonary complications.

Typical roentgenographic features are pneumatoceles, segmental infiltrations, pneumothorax, empyema, and emphysema. Most distinctive is the rapidly changing picture which often cannot be correlated with the clinical course.

Five roentgenograms; 1 photomicrograph.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

**Loeffler's Syndrome, with a Report of Twenty Three Cases.** Louis Mark. *Dis. of Chest* 25: 128-149, February 1954.

The author relates his experience with 23 cases diagnosed as Loeffler's syndrome. In addition to tabulating the clinical, laboratory, and x-ray findings for the whole series, he presents 4 case histories.

Loeffler originally described the syndrome as asymptomatic, but most of the author's patients had symptoms. Parasites were present in only 13 per cent. The diagnosis was based on the occurrence of transient pulmonary lesions plus an eosinophilia.

The x-ray findings show great variation, and not infrequently resemble tuberculosis. Most of the author's cases revealed infiltrating lesions localized in the lower two-thirds of the lungs. These had a cylindroid or patchy appearance, suggesting a blocking of smaller bronchi, differing considerably from the infiltrations of bronchopneumonia, but somewhat resembling a virus

pneumonitis. Many of the shadows had an atelectatic appearance.

Cortisone proved to be almost a specific in treatment. The symptoms disappeared in forty-eight hours, and the lesions cleared completely in five days. Before the advent of cortisone, the author obtained excellent results with blood transfusions.

Thirty-four roentgenograms; 1 table.

HENRY K. TAYLOR, M.D.  
New York, N. Y.

**Byssinosis.** A. Gerson Hollander. *Dis. of Chest* 24: 674-678, December 1953.

"Byssinosis" is a disabling respiratory condition caused by the inhalation of cotton dust over a long period of years. When there is associated cardiac failure, roentgen differentiation from advanced pulmonary tuberculosis may be difficult.

The disease affects carders and strippers in the cotton industry. Although it has been known since 1818, its recognition has been most difficult. This may be because the early symptoms are those of allergy and are not incapacitating. After years of exposure, however, the affected worker becomes incapacitated and the clinical and pathological picture is one of advanced pulmonary emphysema and fibrosis. X-ray examination is of little help in the diagnosis but may reveal emphysema with superimposed right heart failure.

The author reports a case in a 55-year-old white male admitted to a Veterans Administration Hospital in 1949, with dyspnea, cough, and cyanosis. The history dated back to 1939, when the patient was forced to stop working as a framer and carder after twenty years in textile mills. Chest examination at that time revealed extensive peribronchial and nodular infiltrations. The possibility of tuberculosis led to multiple examinations for tubercle bacilli. Of 14 specimens examined one was positive for a few colonies. There was some temporary improvement, but episodes of intense dyspnea and cyanosis recurred. Roentgenograms on admission to the Veterans Hospital again showed extensive peribronchial and nodular infiltrations. About five months later severe cardiac failure ensued. Necropsy revealed voluminous lungs but no tuberculosis. Areas of consolidation and extensive hemorrhagic areas were present. Bronchial and hilar lymph nodes were enlarged. Microscopically there were marked thickening and fibrosis of the alveolar walls, with edema fluid and hemorrhage in the alveoli. The chronicity of the process was indicated by lymphocytes and hemosiderin deposits. Epithelization was prominent in areas of severe fibrosis.

The characteristic pathological picture of marked thickening of the alveolar walls and the history of long exposure to cotton dust with severe, incapacitating symptoms makes the diagnosis of byssinosis most probable. The paucity of reports of the disease in this country, as compared with Europe, may reflect better protection of workers, or it may be that the condition is being overlooked in differential diagnosis and that adequate industrial histories are not being taken. It seems likely that, with improvement in methods for dust control in cotton factories, the disease will be completely eradicated.

Two roentgenograms; 2 photomicrographs.

FRANK T. MORAN, M.D.  
Auburn, N. Y.



**Bronchiectasis Due to Aspergilloma.** G. D. Pesle and Olivier Monod. *Dis. of Chest* 25: 172-183, February 1954.

Aspergilloma is a special form of pulmonary mycosis characterized by a tumor made up of accumulated mycelium filaments, due to *Aspergillus*, occurring in a distended bronchus. The authors report 3 cases of their own and summarize 6 cases from the literature. Clinically there are repeated hemoptyses, with no evidence of tuberculosis. The roentgenogram shows a solitary lesion, round or ovoid, not very dense, capped by a thin crescent-shaped area of radiolucency which the authors call an "aerial tegmentum." The lesion presents an appearance resembling a cavity surrounded by a thin line, as in an air cyst. There is no involvement of the surrounding lung. The mass does not progress in size, and the bronchus is not occluded.

The authors believe that aspergilloma arises within the bronchus, and that associated bronchiectasis is secondary. Seven of the lesions occurred within the apical portions of the upper lobes, and two within the lower lobes.

Five roentgenograms; 4 photomicrographs; 1 photograph. HENRY K. TAYLOR, M.D.  
New York, N. Y.

**Bilateral Hilar Lymphadenopathy: Its Association with Erythema Nodosum.** N. Wynn-Williams and Gordon F. Edwards. *Lancet* 1: 278-281, Feb. 6, 1954.

Between January 1947 and June 1953, the authors observed 17 cases of bilateral hilar adenopathy, of which 12 were associated with erythema nodosum. During the same period, 15 patients with sarcoidosis and 49 with erythema nodosum without hilar adenopathy were seen.

Three of the patients with bilateral hilar adenopathy were symptomless. The remaining 14 had symptoms which, in order of frequency, were erythema nodosum, polyarthritis, lassitude, dyspnea, malaise, and loss of weight. These symptoms had been present from two to twelve weeks before discovery. In 7 patients polyarthritis developed, usually from four to six weeks before the onset of erythema nodosum, after which the arthritis rapidly and completely resolved. In 12 patients resolution of the erythema nodosum was followed by disappearance of symptoms within three to six weeks.

In every instance the diagnosis of enlarged hilar nodes was made roentgenologically. The criteria used were that the enlargement be well marked and undoubted, that definite lobulation of the hilar shadows be present, and that independent opinion also consider the hili to be enlarged. In 5 patients it was possible to obtain a chest roentgenogram before onset of the hilar adenopathy, and in 9 patients a regression of the shadows was observed, confirming the diagnosis.

In 5 cases the lymph nodes returned to normal within six months; in 3 cases they were smaller in six months and normal in twelve months, and in 2 cases there was no change in nine months. All of these patients presented with erythema nodosum. In another patient, observed for twenty-four months, the nodes became smaller but were still enlarged at the time of the report. In still another case enlargement of the hilar nodes, which was accompanied by normal lung fields, disappeared within six months, but a year later the hilar shadows again enlarged and the lung fields showed

generalized fine nodulation throughout. This second episode was again followed by complete radiological resolution in just under a year. These last 2 patients presented with symptoms but without erythema nodosum. The remaining 5 patients had been under observation for less than six months, and there had been no change in the enlargement. In 6 of the 17 cases minimal nodular shadows were demonstrable in the lung fields at the time of the enlargement of the lymph nodes; in 4 of the 6 there was associated erythema nodosum. These changes extended well over the equivalent of a third of a lung field, and might well have been considered as prominent vascular markings, apart from their later disappearance simultaneously with the enlarged hilar shadows. The changes in all these cases was confirmed by tomography.

The authors discuss the relationship of hilar adenopathy and sarcoidosis. Evidence, in their opinion, suggests that hilar adenopathy is a milder or abortive form of sarcoidosis. They believe that both conditions are relatively common.

Five roentgenograms; 1 table.

**Preclinical Bronchogenic Carcinoma.** Katharine R. Boucot and Martin J. Sokoloff. *Am. Rev. Tuberc.* 69: 164-172, February 1954.

Of a total of 77 proved cases of bronchogenic carcinoma discovered in photofluorographic surveys, 50 were considered preclinical, since the patients had not sought medical attention and the survey was the only means for detection of the tumor. The rate of occurrence of bronchogenic carcinoma was 30 per 100,000 persons examined, with the incidence in males more than ten times that in females. Prevalence in persons over forty-five years of age was more than fifty times that in persons under forty-five.

Of the 77 patients, only 18 per cent survived the follow-up period of three months to six years. Previous films were available in 22 cases and had been reported as normal. On review, 11 of these were found to have some indication of the disease, while the other 11 showed no abnormality. All of the patients in the latter group have died. The median interval between a normal and the first recognized abnormal photofluorogram was seventeen months. Of the 11 patients whose films were at first erroneously interpreted as normal, 4 had resections and are alive eight to fifty-two months following surgery, while a fifth survives without surgery. Although the lesions were discovered in surveys of the general population, only 10 per cent of the patients were found to be completely asymptomatic on close questioning.

The findings suggest the need for more frequent chest films in males over forty-five, with comparison of previous films at each reading and a high index of suspicion when any abnormality appears. In patients with symptoms but with normal roentgenograms, careful clinical study is indicated.

Five tables. JOHN H. JUHL, M.D.  
Minneapolis, Minn.

**On the Frequency of Bronchogenic Carcinoma under the Guise of the "Middle-Lobe Syndrome."** K.-H. Ueberschär and E. Hasche. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 208-214, February 1954. (In German)

The so-called "middle-lobe syndrome" represents chronic atelectasis or pneumonitis of the right middle

lobe with bronchostenosis due to inflammatory perihilar adenopathy. Neoplasm has been considered to be rarely the cause of the syndrome since only 0.7 per cent to 5.5 per cent of all bronchogenic carcinomas are localized in the right middle lobe. Contrary to this impression, the authors found underlying neoplasm in 10 of a series of 20 middle-lobe-syndrome cases, representing 3 per cent of all bronchogenic carcinomas seen over the same period.

Two verified malignant cases are reported and illustrated. In the first case local calcifications suggested the middle lobe syndrome. Tomography, bronchography, and bronchoscopy all failed to suggest a neoplasm. In the second case the bronchographic findings were slightly suggestive of a neoplastic process involving the medial segment.

Calcified lymph nodes and absence of a tumor shadow are of no value in ruling out carcinoma. Therefore, immediate surgical therapy is advised. Delay for follow-up observations is contraindicated and probably has been the cause of 60 per cent inoperability. In only 1 case in the authors' series was radical resection successful.

Six roentgenograms.

E. KRAFT, M.D.  
Newington, Conn.

**Causes of Death in Carcinoma of the Lung in a Large Public Hospital. An Analysis of 186 Fatalities.** Frederick Fitzherbert Boyce. *Dis. of Chest* 24: 626-641, December 1953.

In addition to medical and surgical errors and missed opportunities, fundamentally unfavorable circumstances which there seems to be no way of overcoming were found by the author in his analysis of 186 recent deaths from carcinoma of the lung recorded at the Charity Hospital of Louisiana (New Orleans).

The study of these records bore out the overwhelming predominance of male patients, with the greatest concentration between fifty and seventy years. Operation was not performed in any patient under forty years of age.

The hospital mortality for carcinoma of the lung treated by pneumonectomy was 28 per cent, which is no higher than the mortality described in other reported series. The chief reason for so high a figure is probably the extension of the indications for the operation to borderline cases and doubtful risks.

The author mentions several causes of delayed diagnosis: (1) acceptance of negative roentgen findings as conclusive, without further investigation; (2) the promiscuous use of antibiotics and cough medicines, with clearing of associated infection and consequent amelioration of symptoms; (3) concentration of attention upon concomitant disease, even though indications of a chest lesion may be present; (4) the increasingly frequent tendency to explain symptoms on psychosomatic grounds; (5) omission of bronchogenic carcinoma from the list of diagnostic possibilities after admission examination.

In most of the author's series there was no lack of diagnostic investigation. In 170 cases chest roentgenograms were made; in only 7 instances were these reported negative. Fifty-eight of 104 bronchoscopic examinations were positive for carcinoma. This latter number is relatively small because of the location of most neoplasms, where they cannot be visualized.

It is concluded that, to lower the mortality in this disease, the medical profession must (1) develop a

much higher index of suspicion; (2) explore the chest more often on suspicion; (3) emphasize the urgency of diagnosis and treatment; (4) investigate the whole individual rather than limited fields when adults seek medical care for any reason whatever; (5) make the most possible use of data available in mass chest surveys.

Three graphs.

FRANK T. MORAN, M.D.  
Auburn, N. Y.

**Bronchopulmonary Sarcoma.** Lalla Iverson. *J. Thoracic Surg.* 27: 130-148, February 1954.

In the period 1900-50 there have been reported only 16 cases of presumably primary spindle-cell sarcoma of the lung. The author adds 3 cases from the Armed Forces Institute of Pathology and tabulates the findings in the complete series.

Characteristically the primary sarcomas of the lung were solitary, firm, white tumors occurring in middle-aged persons. The degree of encapsulation tended to vary with the degree of cellular differentiation. The capsule, when intact, was dense and fibrous but not always did it restrain the tumor from expanding into the adjacent parenchyma. Metastatic sarcomas, although usually poorly encapsulated, may on occasion present gross features identical with those of the primary tumors. Microscopically, the pulmonary sarcomas are composed of spindle-shaped cells with varying amounts of intercellular material or cellular fibrils, which may stain as collagen reticulum or smooth muscle. Usually reticulin is the only positive-staining product.

Because of the peripheral location of the intrapulmonary spindle-cell sarcoma, the clinical course is usually long and the symptoms are non-specific. The tumor is encapsulated and therefore lends itself to removal by lobectomy or pneumonectomy. Metastasis or recurrence occurred in only 6 of the 19 cases reported. It is probable, however, that these tumors have the same potentiality for late metastasis as tumors of similar histologic types originating elsewhere.

Endobronchial spindle-cell sarcomas can be distinguished from the parenchymal spindle-cell pulmonary sarcomas. They are more unusual than the parenchymal type, occur in younger individuals, are discovered earlier, and are relatively more benign. The authors report a total of 8 such cases, including 3 of their own. Other types of mesodermal sarcomas such as liposarcoma, rhabdomyosarcoma, and chondrosarcoma are very rare and only isolated examples have been reported.

The accurate histologic diagnosis of bronchopulmonary sarcoma is complicated by similar appearing lesions which occur more frequently. These are: (a) undifferentiated-cell bronchogenic carcinoma, (b) post-inflammatory fibroblastic repair, (c) polypoid epidermoid carcinoma with sarcomatoid differentiation, and (d) pleomorphic-cell carcinoma of the bronchus, which is often diagnosed myosarcoma or rhabdomyosarcoma.

Thirteen photographs and photomicrographs; 3 tables.

RENÉ FORTIER, M.D.  
St. Paul, Minn.

**Benign Tumours of the Lung.** Clement Price Thomas. *Lancet* 1: 1-7, Jan. 2, 1954.

In a series of 450 cases of lung tumor operated on by the author at Brompton and Westminster Hospitals,

London, there were 57 benign tumors and 402 carcinomas. This comparatively low incidence, however, does not diminish the clinical significance of the benign tumor. In a large majority of cases, if the condition is not recognized, the complicating element of infection induces a high morbidity, leading not only to a life of prolonged invalidism but also to permanent and irreparable damage to the area of the lung situated beyond the site of the tumor. If diagnosis is made early in the evolution of the process, local removal is possible, without the sacrifice of any normal lung tissue. The earliest findings of significance will be the roentgen evidence of a circumscribed shadow, when the lesion is interstitial; the presence of an area of emphysema with or without the normal changes in translucency occurring with inspiration and expiration; and often signs of overinflation or of deflation of the area of lung involved.

Of the 57 benign pulmonary tumors, 41 were so-called bronchial adenomas, 10 hamartomas, 4 vascular tumors, and 2 endobronchial fibromas. The author discusses each type and presents illustrative roentgenograms and photographs of operative specimens.

Nineteen illustrations.

**Inhaled Intrapleural Foreign Body. Report of a Case.** D. N. Ross. *Brit. J. Surg.* 41: 412-414, January 1954.

There are several reported cases of inhaled foreign bodies which have progressively worked their way along the distal bronchi and through the lung substance to present as an abscess in the chest wall. Seydell (*Arch. Otolaryng.* 26: 189, 1937) collected a series of 10 such cases in which the foreign body was an ear of wheat or barley. This has the power of spontaneous progression down the bronchi due to the protruding barbs and the associated contraction of bronchial musculature. Infrequently the foreign body makes its way through the lung into the pleural cavity to be found at autopsy or, as in the case here reported, during the course of a lobectomy for bronchiectasis.

The author's patient was a thirty-three-year-old male, with a diagnosis of right middle and lower lobe bronchiectasis. Roentgenograms showed an irregular opacity in the right lower lobe but no foreign body was detected on bronchoscopy. A right lower lobectomy was carried out and a complete ear of barley was found lying free in the pleural cavity in the posterior costophrenic angle. There was a fistulous tract leading into the right lower lobe bronchus, which showed considerable chronic inflammation and bronchiectasis.

One roentgenogram; 2 photographs; 1 table.

WYNTON H. CARROLL, M.D.  
Shreveport, La.

### THE CARDIOVASCULAR SYSTEM

**Performance of Angiocardiography and Cardiac Catheterization as a Combined Procedure.** Robert B. Dickerson. *Am. Heart J.* 47: 252-269, February 1954.

The author describes a combined routine procedure for angiocardiography and cardiac catheterization. The angiocardiographic examination is performed first; if it is inconclusive, catheterization is accomplished.

Premedication consists of a barbiturate, Demerol, and quinidine, with dosage adjusted for age and weight.

Light general anesthesia with local infiltration is used for infants and small children. A segment of the median basilic vein, about 3 cm. long, is exposed, and a polyethylene tube is inserted at the junction of its upper and middle thirds, the tip being passed well into the superior vena cava. In infants of less than a year the injection is made into the femoral vein. Under fluoroscopy, a test dose of 2 c.c. of the contrast medium [not specified] is slowly injected. This serves to opacify the tube, which may then be re-positioned if necessary. At this point, Demerol is administered through the tube and oxygen by mask. The patient is now positioned on a tilted film changer, the medium is injected, and 14 or 16 exposures are made at half-second intervals. The amount of medium used is 1.0 c.c. per pound of body weight up to 15 pounds.

When exposures are satisfactorily completed, usually in two planes, the polyethylene catheter is replaced with a cardiac catheter, and catheterization is performed under fluoroscopic control. Two innovations in this procedure have been introduced: (1) Outlets from a Twin-Viso Recorder are connected to a cathode-ray oscilloscope with a P-7 screen (persistent image screen). This permits the operator to view either the patient's electrocardiogram or intracardiac pulse pressure during the procedure. (2) An audioamplifier and loud speaker attached to a small microphone in the patient's axilla enable the operator to hear extrasystoles at the same time that he sees their form on the oscilloscope screen. The Stethetron electric stethoscope may be used for auditory monitoring of rate and rhythm.

Oxygen is administered for five minutes before, during, and after the administration of the contrast medium in order to prevent an increase in coronary anoxia.

The juxtacardiac injection of the contrast material by way of the basilic vein decreases dilution and results in better diagnostic films. There is less caval reflux, the time of single chamber opacification is thus decreased, and the reliability of opacification and reopacification of individual chambers is enhanced.

Seven case histories are included.

Forty roentgenograms; 1 photograph.

HENRY K. TAYLOR, M.D.  
New York, N. Y.

**Anomalous Pulmonary Vein Entering the Inferior Vena Cava Examined by Selective Angiocardiography.** H. Arvidsson. *Acta radiol.* 41: 156-162, February 1954.

Anomalous pulmonary veins entering the right auricle or its tributaries are of two main types: (1) those entering a persistent left superior vena cava, with passage to the right auricle by way of a left innominate vein or the coronary sinus; (2) those going to the superior or inferior vena cava or directly into the right auricle.

Symptoms arise when significant amounts of blood are shunted consistently through the lesser circulation. This gives rise to increased pulmonary blood volume and to a decrease in oxygenated blood reaching the systemic circulation.

Occasionally the roentgen diagnosis may be made on a routine chest film by observing wide vessels curving downward along the cardiac border. The most reliable means of diagnosis is by angiocardiography in association with catheterization and blood gas analysis.

An illustrative case is reported.  
Five roentgenograms; 2 tables.

RICHARD E. OTTOMAN, M.D.  
University of California, L. A.

**Aortography and Pneumography.** Walter M. Kearns. *Wisconsin M. J.* 53: 139-142, February 1954.

Translumbar abdominal aortography and presacral pneumography complement each other and augment or support routine urographic examinations. A number of previously unsuspected conditions were unearthed in a series of 45 patients in whom these procedures were used by the authors.

With a No. 16 needle 15 to 20 c.c. of 75 per cent Neo-Iopax is injected into the aorta while the arterial circulation to the legs is momentarily arrested by inflation of cuffs placed just above the knees. [This latter procedure has been found unnecessary by others—R.E.B.] The usual roentgenographic technic calls for exposures of one-tenth of a second, at 70 kv., 200 ma., with variations according to the patient's size.

Pneumography is performed by injection of 400 c.c. of oxygen through a No. 18 spinal puncture needle which has been inserted at a point 2 cm. lateral to the sacrococcygeal joint and directed to the mid-line in the presacral and postrectal tissue. The injection precedes aortography by thirty minutes.

Various renal and arterial abnormalities were demonstrated by this means. No harmful effects attended the procedures.

Four roentgenograms.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

**Angiopneumography in the Study of the Pharmacodynamic Properties of Certain Drugs.** Lopo de Carvalho. *Dis. of Chest* 25: 121-127, February 1954.

The author employed opacification of the pulmonary blood vessels (angiopneumography) in rabbits in order to observe the changes produced in the lesser circulation and upon the heart by certain drugs, particularly the vasoconstrictors. This preliminary report concerns adrenalin, pituitrin, and isonicotinic acid.

The retarding effect of these drugs upon the circulation was clearly demonstrated on serial films, and the findings were confirmed by determinations of pulmonary circulation time by single slit kymography.

The author recommends angiopneumography as a means of recording the effects of drugs on the pulmonary circulation.

Nineteen roentgenograms.

HENRY K. TAYLOR, M.D.  
New York, N. Y.

**Translumbar Aortography.** James M. Sullivan, Theodore J. Pfeffer, and Robert A. Frisch. *Wisconsin M. J.* 53: 143-147, February 1954.

Though translumbar aortography has been employed for two decades in the study of renal disease, its use in the diagnosis of peripheral arterial disease is relatively recent. It has been found useful in determining the location and extent of arteriosclerotic processes, aneurysms, and emboli. Postoperatively it determines the efficacy of surgical treatment of these conditions.

The authors' experience includes 20 cases. Six of these are presented to illustrate a normal abdominal

aortic angiogram, iliac thrombosis, iliac embolus, aortic aneurysm, and aortic occlusion.

Six roentgenograms; 1 drawing.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

**Arteriography and Vascular Studies in Paget's Disease of Bone.** Kenneth A. Storsteen and Joseph M. Janes. *J.A.M.A.* 154: 472-474, Feb. 6, 1954.

Arteriography on 2 patients, supplemented by circulatory studies in 1, and circulation studies alone in a third, add further evidence in support of the opinion that multiple small arteriovenous communications in bone are associated, either as cause or effect, with Paget's disease. Arteriograms showed enlargement of arteries and increased collateral blood supply in the region of the osseous deformity. No fistulas were actually demonstrated. One of the 2 cases tested showed marked elevation of venous pressure and slight increase in venous oxygen saturation in the affected extremity.

Three roentgenograms; 1 table.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

**Venography. A New Technique.** George J. D'Angelo, Robert J. Reeves, Robert L. Pinck, and J. Edward King. *Am. J. Roentgenol.* 71: 224-227, February 1954.

The authors describe a new venographic technic by which it is possible to visualize the entire deep venous system of a limb on a single film. They utilize an opaque plastic wedge filter constructed on a 0.5 mm. aluminum filter plate, which is then inserted into the filter slot of the tube. This allows a comparable penetration of both the thicker portion of the thigh and the thinner leg structure. A 14 X 36-inch film and a long Bucky are employed in order to visualize the entire venous system from groin to ankle.

The third feature of the technic is the triple exposure of film. Forty cubic centimeters of 50 per cent Diodrast solution is injected into the lower end of the small saphenous vein through a polyethylene tube, in approximately forty-five seconds. An exposure is made at a point half-way through the injection, again at the completion of injection, and finally thirty seconds after the injection. Three exposures are then obtained on a second film, at thirty-second intervals. A third film can be similarly exposed if delayed venous flow is suspected. Reproductive organs are covered with a lead shield.

Satisfactory venograms are obtained at 70 kv., one-half second exposure, and 5 feet target-to-film distance. These factors are kept constant and the milliamperage is varied between 150 and 300.

Two roentgenograms; 2 drawings.

DAMON D. BLAKE, M.D.  
University of Arkansas

**Clinical Application of Portal Venography.** H. Fuld and D. T. Irwin. *Brit. M. J.* 1: 312-313, Feb. 6, 1954.

The authors have performed portal venography by percutaneous intrasplenic injection on over 50 occasions. In most instances a single exposure was made after the injection of 18 c.c. of a 50 per cent diodone solution. The needle was introduced in the left posterior axillary line just below the tenth rib, with the



patient on his back. Several times the spleen was missed and the contrast material was injected into the peritoneal cavity, and, on one occasion at least, into the splenic flexure of the colon, but no ill effects followed.

Intrasplenic portal venography has been found useful in the diagnosis of splenomegaly of unknown origin, in the differentiation of intrahepatic and extrahepatic venous block, and in the assessment of the degree of portal hypertension and the anatomy of the anastomosis between the splenic vein and gastric and esophageal vessels.

The technic presents no difficulties in patients with enlarged spleens; in those with normal spleens, failure to enter the splenic tissue is frequently encountered due to the mobility of the organ.

Six venograms.

THEODORE E. KEATS, M.D.  
University of California, S. F.

**Thrombosis of the Abdominal Aorta and Iliac Arteries.** Bruce R. Heinzen, Howard S. Dunbar, and Herbert Parsons. *Ann. Surg.* 139: 148-157, February 1954.

Only during the past twenty-five years has it become possible to make an accurate diagnosis of thrombosis of the abdominal aorta and iliac arteries by means of aortography. The case histories of 14 patients are presented in this report. Thrombosis of the abdominal aorta or the iliac arteries, or both, was suspected from the clinical findings and the diagnosis was established by aortography. In 12 of the 14 cases it was further confirmed by direct examination of the arteries at surgery.

From a study of this group of patients it would appear that in most instances the development of thrombosis occurs as the result of arteriosclerotic changes in the vessels involved.

The methods of treatment are outlined and evaluated. The most satisfactory procedure was removal of the thrombus in those cases in which this was feasible. Good results were also obtained in cases where the thrombosed segment could be resected and successfully grafted.

Thirteen roentgenograms; 1 photograph; 1 table.

CARLYNE A. NEWMAN, M.D.  
Cleveland City Hospital

**Arachnodactyly Associated with Aneurysm of the Aorta.** Howard S. Traisman and Frank R. Johnson. *Am. J. Dis. Child.* 87: 156-166, February 1954.

Two cases exemplifying the typical findings of Marfan's syndrome (arachnodactyly) with an associated aortic aneurysm are reported, with autopsy findings. These are believed to be the twentieth and twenty-first autopsied cases of arachnodactyly to be reported, and the patients, nine months and ten years of age, respectively, are thought to be the youngest exhibiting arachnodactyly and associated aortic aneurysm.

Four photographs; 2 photomicrographs.

## THE DIGESTIVE SYSTEM

**Esophageal Diverticula.** Frank H. Lahey and Kenneth W. Warren. *Surg., Gynec. & Obst.* 98: 1-28, January 1954.

This very comprehensive article, approaching a monograph in scope, is concerned for the most part with the surgical technic of the two-stage operation for

the pharyngo-esophageal diverticulum. Only that portion relating to diagnosis is abstracted here.

The lowest inferior constrictor muscles of the pharynx and the cricopharyngeal fibers are given off obliquely at the pharyngo-esophageal junction and produce, in this small triangular area, a weak spot, which has been called the "pharyngeal dimple." This dimple may give way under pressure to form a small sac. As it increases in size, the sac becomes longer. The origin remains fixed and the sac, while in the neck, is limited in transverse diameter by the muscles. The direction of enlargement is therefore along the only unobstructed pathway—downward and into the mediastinum. The downward descent is also related to the weight of the food-filled sac.

There are three stages in development of a pharyngo-esophageal diverticulum. The first is only a bulge of the mucosa and submucosa through the dimple. In the second stage the sac is somewhat globular, but the opening is almost in a vertical plane, so that food can still follow a direct pathway into the esophagus, by-passing the diverticular orifice. In the third stage the large, elongated sac has weighed so on the esophagus that the diverticular opening is now almost horizontal, while the direct pathway into the esophagus is at an oblique angle, so that the food tends to pass into the diverticulum and enters the esophagus only by a spill-over. The diverticulum may attain such a size that it presses upon the esophagus below the diverticular orifice and actually obstructs it. In such cases attempts to pass a bougie or esophagoscope may result in perforation of the diverticulum. These procedures are frowned upon as unnecessary and dangerous.

The roentgen diagnosis depends on demonstration of the barium-filled diverticulum and its orifice in the lateral view. In the anteroposterior view an esophageal web with dilatation of the pharynx above it may simulate a diverticulum. A semilateral view in such cases will fail to show the spill-over into the esophagus characteristic of a diverticulum.

While an irregular filling defect in a diverticulum may be produced by food particles, the possibility of an associated carcinoma must be considered and the surgeon warned.

The authors include a short discussion of epiphrenic pulsion diverticula, and their similarity to pharyngo-esophageal diverticula is noted. The mechanism of production is obscure. Traction diverticula are also mentioned, in passing. They rarely require surgery.

Twenty-three illustrations, including 10 roentgenograms.

GEORGE R. KRAUSE, M.D.  
Mt. Sinai Hospital of Cleveland

**Segmental Esophagitis, Gastritis and Enteritis.** Elmer W. Heffernon and Paul H. Kepkay. *Gastroenterology* 26: 83-88, January 1954.

The authors report an unusual case of chronic inflammatory reaction of non-specific etiology involving the esophagus, stomach, and small intestine in a forty-eight-year-old white male, with definite remissions and exacerbations. Perforating ulcers of the third portion of the duodenum eventually led to death.

Radiological findings include a polypoid mass approximately 2 cm. in diameter in the lower esophagus, distortion and hypertrophy of the gastric rugae, and disturbed motility, dilatation, and an irregular mucosal pattern of the small bowel. Esophagoscopy showed inflammation of the lower esophagus and confirmed the



presence of the polypoid mass. The biopsy report was chronic non-specific inflammatory changes without ulceration.

The patient was put on an intensive ulcer regime, and after six weeks esophagoscopy and barium studies revealed a normal esophagus. Five months later, following another episode of nausea, vomiting, and weight loss, a gastrointestinal series showed large gastric rugae with marked deformity of the entire duodenum and two penetrating ulcers of the third portion at the ligament of Treitz. At operation the jejunum was found to be greatly thickened for a distance of 3 feet; it was extremely pale and presented the appearance of chronic regional jejunitis. Two large ulcers in the posterior wall of the duodenum had perforated and become attached to tissues lying immediately anterior to the aorta. Surrounding these was a severe inflammatory reaction. Death occurred eight days later.

Eight roentgenograms; 2 photomicrographs.

A. J. NICHOLAS, M.D.  
Shreveport, La.

**Case Reports of Tuberculosis of the Esophagus.** W. Pulver and F. Michel. Schweiz. med. Wchnschr. 84: 221-223, Feb. 13, 1954. (In German)

Tuberculous involvement of the esophagus is rare and may be easily mistaken roentgenologically for carcinoma, since characteristic roentgen changes are lacking. Four cases have been observed by the authors in the past four years. The disease may remain undiscovered during life, since it is frequently asymptomatic. When roentgen findings are positive, biopsy is indicated to rule out carcinoma.

The lesions may develop from a remote focus through hematogenous or lymphatic spread or may be caused by inoculation or implantation. Most frequently, however, the disease spreads from tracheobronchial and paraesophageal nodes, occasionally with perforation into the esophagus. Pathologically, ulcerative, sclerotic, stenosing, and granulomatous changes are known to occur. The advanced age of the authors' patients was striking.

The first patient was a male aged eighty-seven, with dysphagia and an erroneous roentgen diagnosis of carcinoma. Autopsy revealed a tuberculous ulcer of the esophagus, hematogenous spread to various organs, fibrocalcific infiltration of the pulmonary apices, and a calcified hilar node.

The second patient was a male of sixty-four years who suffered from hoarseness and dysphagia. The roentgen diagnosis was carcinoma, but biopsy revealed a superficial ulcer with chronic non-specific inflammation. At autopsy tuberculous nodes were found.

The third case was that of a woman of sixty-four, who suffered from cough, fatigue, and dyspnea. Because of roentgen findings of hilar adenopathy a radio-therapeutic test was tried, but soon afterward a tuberculous tracheo-esophageal fistula developed with fatal outcome.

The fourth patient, a male, died at the age of seventy-six of pulmonary tuberculosis without esophageal symptoms. At autopsy caseous lymph nodes were found, with perforation into the trachea and esophagus; also squamous-cell carcinoma of the esophagus with spread to regional lymph nodes.

Four roentgenograms; 1 photograph.

E. KRAFT, M.D.  
Newington, Conn.

**Perigastritis Deformans Following Left-Sided Pulmonary and Pleural Diseases.** E. Minder. Schweiz. med. Wchnschr. 84: 189-193, Feb. 6, 1954. (In German)

Attention is called to a perigastritis which develops many years or even decades following chronic left-sided pulmonary or pleural disease. The relationship can be explained by the numerous lymphatic channels which connect the pleural cavity with the peritoneal cavity through the diaphragm. There are symptoms of chronic spastic dyspepsia, with a sense of pressure and fullness and cramp-like pains not related to meals. No remission is noted, but only a slight change of intensity, especially when the body position is altered. There are frequent eructations, heartburn, and nausea and vomiting. Complications are hemorrhage, constipation, weight loss, hyperhidrosis, and tachycardia.

Pathologically, the inflammation spreads from the parietal to the visceral serosa and causes adhesions which result in the following deformities: (1) perigastritis near the cardia with traction diverticulum, (2) cascade stomach, (3) fixed gastropexia. Roentgen findings are gross deformities of the stomach with irregular contour, narrowing leading to stenosis, fixation of gastric fundus, cascading, kinking, and finally torsion and incomplete volvulus.

Four cases are reported and illustrated. The first patient was a housewife, aged sixty-three, with a long history of chronic pneumonitis, bronchiectasis and pleurisy on the left side. Spastic dyspepsia with weight loss developed at the age of sixty-two. Roentgen examination showed a fish-hook stomach, fixation of the gastric fundus at the diaphragm, and clockwise rotation and torsion along the longitudinal axis of the stomach. The second patient, a male, of forty-seven, had empyema of the left pleural cavity in 1945, followed by spastic dyspepsia, constipation, and weight loss. In 1953, films showed cascading of the gastric fundus with pseudodiverticulum, kinking, and stenosis, so that only small amounts of barium trickled into the lower half of the stomach.

The third case was that of a female of forty-four years with a history of left-sided pleurisy at eight years. The stomach was always sensitive, but spastic dyspepsia did not develop until the age of forty-three. Roentgen findings were high fixation of the left hemidiaphragm with obliteration of the left costophrenic sinus, large pseudodiverticulum at the lesser curvature side near the cardia, and fixation of the gastric fundus. The fourth patient, a female aged thirty-eight, had had left-sided pneumonitis and pleuritis at the age of thirteen. Gastric symptoms developed three years later, becoming accentuated in the course of years. Roentgen findings were pleural thickening at the left base and cascading of the gastric fundus.

Six roentgenograms; 2 drawings.

E. KRAFT, M.D.  
Newington, Conn.

**Hypertrophy of the Pyloric Muscle in Adults.** John W. Stinson, August V. Casillo, and Earl Harter. Pennsylvania M. J. 57: 139-142, February 1954.

The authors have seen 5 cases of hypertrophy of the pyloric sphincter in adults, 3 of which they describe in detail. Though the condition has been reported more frequently in males, 4 of this series were females. The symptoms are usually epigastric fullness, pain, vague discomfort, and vomiting. Roentgen examination

shows an elongated pylorus and a 25 to 50 per cent retention of barium at six hours. Three of the authors' patients had associated gallstones. At operation the usual finding is a firm tumor mass or hypertrophy of the pyloric muscle. The treatment is surgical—either pyloroplasty or gastric resection.

An important point in differentiating hypertrophy of the pyloric muscle from gallbladder disease is the occurrence of vomiting, which is unusual in the latter condition unless common duct stones are present. The authors believe that the diagnosis should be made more frequently because of the suggestive history and x-ray findings.

Four roentgenograms.

PAUL MASSIK, M.D.  
Quincy, Mass.

**Ferrous Sulphate Poisoning Causing Pyloric Obstruction.** Isabella Forshall and P. P. Rickham. *Brit. J. Surg.* 41: 379-381, January 1954.

Pyloric obstruction following the ingestion of caustics is a well known complication. This is a report of 2 cases due to ferrous sulfate poisoning following the ingestion of Fersolate tablets. The patients were children seventeen and thirteen months of age, respectively, and history, clinical, radiological, and operative findings were very similar in the 2 cases. These are believed to be the first examples of pyloric obstruction due to this cause.

Three roentgenograms.

WYNTON H. CARROLL, M.D.  
Shreveport, La.

**Reticulum-Cell Sarcoma of the Gastrointestinal Tract.** J. MacKenzie and R. F. Robertson. *Gastroenterology* 26: 70-82, January 1954.

A case of primary gastrointestinal reticulosis (reticulum-cell sarcoma) is reported, illustrating the similarity of the radiologic and gastroscopic appearances to those of giant hypertrophic gastritis. The patient was a forty-one-year-old coal miner with somewhat vague symptoms. Radiologically the esophagus was normal. The stomach showed marked hypertrophic rugae with loss of their regular parallel symmetry along the lesser curvature but gastric motility was normal. The duodenal cap showed a spiky outline. In at least two areas in the jejunum and ileum there were rounded filling defects. Filling defects also occurred in the ascending colon and cecum, the latter showing an "almost polypoid" appearance. At re-examination a month later these findings were unaltered. Gastros-copy was done, and on the basis of the radiologic and gastroscopic observations a provisional diagnosis of giant hypertrophic gastritis was made.

About three months later examination revealed a small hypertrophic lesion high in the right lateral rectal wall, and a biopsy was taken. The pathological report suggested malignant reticulosis or reticulum-cell sarcoma. Severe colicky pains subsequently developed and laparotomy revealed three intussusceptions. The small intestine was diffusely involved with nodular masses, and the mesenteric lymph nodes were enlarged. A large mass of firm nodes was encountered in the region of the cecum. Gastrostomy showed thickened mucosal folds and there was palpable thickening of the duodenum. Biopsies from the stomach and mesenteric lymph nodes confirmed the previous findings of reticulum-cell sarcoma.

X-ray therapy was instituted without delay and

was followed by clinical improvement and disappearance of the roentgen changes in the gastrointestinal tract except for some residual alteration of the mucosal pattern in the terminal ileum and cecum.

The value of early diagnosis in primary gastrointestinal reticulosis is illustrated by the excellent response to deep x-ray therapy in this case.

Seventeen roentgenograms; 1 photomicrograph.

A. J. NICHOLAS, M.D.  
Shreveport, La.

**Roentgenologic Studies of the Intestine in Normal Infants and in Colonic Hyperperistalsis in Neurolabile Infants.** Sigvard Jorup and Sven Roland Kjellberg. *Acta radiol.* 41: 109-131, February 1954.

In so-called dyspepsia in breast-fed infants it is characteristic for defecation to occur during each feeding and occasionally between feedings. The infants are restless and irritable during feeding, often have attacks of abdominal pain, and may stop sucking. The condition usually develops during the first week of life and disappears before the third or fourth month.

Roentgen studies of the upper gastrointestinal tract in 38 normal children between the ages of one week and four months of age and 111 children ranging from two weeks to eleven months of age exhibiting dyspepsia during breast feeding revealed no differences between the two groups in peristalsis, gastric emptying, or small bowel activity. Twelve to fifteen seconds after the infant began feeding, vigorous intestinal motility began propelling the barium onward. After thirty-five to forty-five seconds it could be observed in the middle third of the small bowel and usually reached the terminal ileum in eighty to one-hundred-five seconds. In the ileum the peristaltic activity was less vigorous, the contractions were of a more kneading variety, and the transit rate slower.

Study of the colon in these two groups of infants was accomplished by barium enema. In the normal infants the enema was easily administered at a pressure of approximately 50 cm. of water. The colon dilated to a considerable width, and after defecation fairly large quantities of barium remained in the relatively distended bowel. No appreciable motility was visible in the colon during feeding. In the dyspeptic breast-fed infants, increased pressure was necessary for filling the colon. In severe cases, the entire colon contracted vigorously and practically all the barium was expelled in a short time.

Good therapeutic results were obtained in this group of dyspeptic infants with the use of methylscopolamine administered twenty to thirty minutes before each feeding. The drug decreases the excitability of the autonomic nervous system.

Since virtually all these dyspeptic infants exhibited neurolabile symptoms and since most had parents exhibiting neurolability and a high incidence of "nervous" gastrointestinal symptoms, the authors feel it is probably appropriate to refer to this syndrome as "colonic hyperperistalsis in neurolabile infants."

Thirty roentgenograms; 6 tables; 1 diagram.

RICHARD E. OTTOMAN, M.D.  
University of California, L. A.

**Intestinal Obstruction in Infants.** Edward B. Singleton. *J. Pediat.* 44: 159-171, February 1954.

A discussion is presented of the radiological features of the various types of obstruction that occur in in-

fants. In interpreting the roentgenograms the radiologist is required to make three major decisions:

1. Is obstruction present?
2. What is the location of the obstructive lesion?
3. What is the etiology?

Extreme normal variations of both the distribution and quantity of gas occur within the intestinal tract of infants and children. Gas reaches the proximal portion of the small bowel during the first hour of life, and by the third hour the entire small bowel contains gas. This time sequence is often delayed until the first feeding, especially if the infant cries little during the interim. Typically, the plain films of the abdomen in the newborn show the small bowel gas pattern as multiple ill defined areas of radiolucency confined for the most part to the left side of the abdomen. The bowel is not distended, and continuity of loops is undetectable. Occasionally, however, an excessive amount of gas may be seen in the small intestine of an infant who has swallowed a great deal of air. The intestinal loops may even be distended. In such cases, gas is also present within the stomach and colon, presenting an appearance which may simulate mechanical obstruction or paralytic ileus.

Fluid levels within both colon and small bowel are not infrequently seen in the absence of obstruction when films are taken with the patient in an upright position. This is especially noticeable in an infant with diarrhea which, if not obvious clinically, will develop within a few hours after the examination.

In view of these observations, it is apparent that, before a diagnosis of obstruction is offered, there must be accurate correlation of the roentgen signs with the clinical picture.

A discussion is presented of the various conditions encountered in children that may produce intestinal obstruction and of the radiographic appearance of these lesions.

Thirty-four roentgenograms; 1 photograph.

HOWARD L. STEINBACH, M.D.  
University of California, S. F.

**Congenital Absence of Part of the Colon Associated with Carcinoma of the Colon.** Kenneth M. Douglas. *Brit. J. Surg.* 41: 373-374, January 1954.

Stenosis, atresia, and absence of part or whole of the colon are the least common congenital lesions. The author reports the case of a thirty-two-year-old female with the very rare abnormality of failure of differentiation of part of the colon. Only the distal half of the colon was present, and this was found at operation to contain a mucoid carcinoma which had penetrated the muscle wall and was growing in the retrocolic fat. The distal portion of the small bowel was dilated and there was a congenital stenosis at its point of junction with the colon. Postoperative roentgen examination confirmed the arrangement of bowel demonstrated at operation. Barium passed to the rectum in five hours without obstruction.

The author was able to find in the literature only one case of association of a congenital lesion of the colon with carcinoma (Sheinfeld: *J. Internat. Coll. Surgeons* 14: 608, 1950). He could find no case in which a segment of the colon was missing, as in his patient.

One roentgenogram; 1 drawing.

WYNTON H. CARROLL, M.D.  
Shreveport, La.

**Amebiasis: A General Discussion with a Report of an Unusual Case of Amebic Granuloma of the Descending Colon.** Edwin E. Goldberg and Frederick Steigmann. *Gastroenterology* 26: 56-64, January 1954.

In view of the relative frequency of amebic granuloma of the colon, it has become exceedingly important to bear in mind its similarity to carcinoma, and to attempt to differentiate these two conditions in which treatment and prognosis are so different. In making the differentiation, the following factors enter into consideration: clinical history, age of the patient, duration of symptoms, presence of *Endameba histolytica* and response to anti-amebic therapy, situation of the lesion (the most frequent sites of amebic infestation are the ceco-appendiceal region and the rectosigmoid), and the roentgenologic appearance.

Bell (Am. J. Roentgenol. 39: 916, 1938. Abst. in Radiology 31: 509, 1938. See also Radiology 32: 332, 1939), describing the roentgen picture in amebiasis, has stressed the significance of changes in the cecum, which he states is characterized by "irregular narrowing of the lumen, at times resembling a comb" and at other times a small pouch. Associated with these changes is an unusual degree of incompetence of the ileocecal valve. Druckmann and Schorr (Am. J. Roentgenol. 54: 145, 1945. Abst. in Radiology 46: 618, 1946) are also quoted. These writers pointed out the following roentgen features as distinguishing amebic granuloma of the lower bowel from carcinoma: (1) longer filling defect; (2) lesions usually multiple; (3) obstruction of the bowel incomplete; (4) pain insignificant or absent upon distention of the bowel by barium; (5) gradual merging of the filling defect into the normal contours of the intestine; (6) partial maintenance of elasticity of the intestinal wall, as evidenced by widening of the lumen upon introduction of barium; (7) more or less mucosal relief pattern; (8) more or less complete restoration to normal after vigorous anti-amebic therapy.

The authors present a case of what they believe was an ameboma of the descending colon in a woman of twenty-six with no history of exposure to amebiasis. The patient manifested a variety of symptoms weeks before diarrhea occurred, which were grouped under the heading psychoneurosis. A barium enema study revealed a napkin-ring-like constriction in the descending colon which had the appearance of carcinoma, and it was only because of the patient's age and severe clinical symptoms that other conditions were considered. Active forms of *Endameba histolytica* were present in the stools. A course of Diodoquin was followed by disappearance of the parasites from the stools and amelioration of the diarrhea, but the patient's general condition did not improve, and as a last resort corticotropin was given. The response to the latter drug was immediate and following a further course of Diodoquin the patient was discharged after one hundred and thirteen days of hospitalization. Two months later she remained symptom-free and refused further studies.

Four roentgenograms.

WINSTON C. HOLMAN, M.D.  
Shreveport, La.

**Volvulus of the Right Colon.** J. Frimann-Dahl. *Acta radiol.* 41: 141-155, February 1954.

Volvulus of the right colon, or cecum, represents some 5 per cent of intestinal obstructions. It is most frequent in the twenty- to forty-year age group but has

been found at all ages from the newborn to ninety years. The present review is based on 23 cases.

The important feature in the pathogenesis of this condition is the presence of a long band-like mesentery with a pedunculated fixation of the cecum to the posterior wall. Demonstration of a distended cecum is the essential point in the roentgen diagnosis. It may be found in any portion of the abdomen but most frequently is seen in the epigastrium and left hypochondrium. If the volvulus is of the "sack" type, *i.e.* showing axial torsion of the colon, one long fluid level is seen; when the torsion is of the "loop" type, in which part of the ileum is twisted around the colon, two fluid levels are observed. Small-bowel distention is a frequent accompaniment of cecal volvulus but is usually not seen in sigmoid volvulus.

The definitive demonstration of cecal torsion is by barium enema. The contrast medium stops abruptly at the point of torsion and shows a twisted and tapered end. This points toward the stenosis and the distended cecum. In cases of axial torsion, reduction may occur as a result of barium enema or even spontaneously with changes in position of the patient.

In the differential diagnosis, volvulus of the sigmoid, volvulus of the small intestine, large bowel obstruction, knot formations, and severe gastric dilatation are to be considered.

Twenty-three roentgenograms; 1 drawing; 1 graph.

RICHARD E. OTTOMAN, M.D.  
University of California, L. A.

**Carcinoma of the Large Intestine. A New Approach to the Study of Venous Spread.** Phil L. Barringer, Malcolm B. Dockerty, John M. Waugh, and J. Arnold Bergen. *Surg., Gynec. & Obst.* 98: 62-72, January 1954.

Carcinoma of the colon and rectum spreads by means of direct extension, peritoneal sedimentation, lymphatic metastasis, and by way of the blood vascular channels. Studies by histologic methods have never given results corresponding with the known frequency with which blood vascular channels disseminate cancer cells. Nearly 50 per cent of those patients whose growths have been removed, with hope of surgical cure, finally succumb to the effects of visceral metastasis, usually because of blood-borne dissemination.

The authors present a new method of approach to the study of intravascular involvement. Forty-five fresh specimens of carcinoma of the large bowel were examined immediately after operation. Two of the patients had known liver metastases; in the others there was no gross evidence of visceral spread and operation was undertaken with hope of cure. Carcinomas from all portions of the colon were studied.

The largest vein was cannulated and the venous bed was perfused with cold tap water. The small vessels on the resected border of the mesentery were sutured. The lumen of the resected bowel was filled with water and the ends tied closed. All major vessels were ligated and marked. A warmed Brominol solution containing a little methylene blue was injected through the cannula until the venous bed was distended to a degree approximating that seen on the operating table. The vein was then tied and the whole specimen placed under cold tap water to harden the Brominol and to wash off any which might have leaked. Roentgenograms were then made and the venous channels were

studied for evidence of obstruction. At any such points blocks of tissue were removed and examined by frozen-section technic, with polychrome methylene blue as a stain. Areas which showed possible involvement were saved for permanent sectioning. Von Gieson's elastic stain was found to be best for this purpose.

In 23 specimens (51 per cent) one or more occluded vessels were found. In 17 of these microscopic study showed venous involvement by metastatic cancer.

The authors suggest that the chief value of their method is to direct attention toward selecting tissue blocks most likely to be "positive." A five-year follow-up study is planned to determine the validity of the assumption that positive evidence of vascular spread in the specimens is reflected in terms of eventual outcome.

Five roentgenograms; 8 photomicrographs; 2 tables.

GEORGE R. KRAUSE, M.D.  
Mt. Sinai Hospital of Cleveland

**Polyps of Rectum and Colon.** Neil W. Swinton. *J.A.M.A.* 154: 658-662, Feb. 20, 1954.

Many patients with polyps of the rectum and colon have no symptoms. Only by the inclusion of sigmoidoscopic and roentgenographic studies of the colon for all patients requiring a complete physical examination are these polyps likely to be found in large numbers. The well established relationship between the benign polyps and cancer in this location makes it essential that the former be found and removed.

This report, from the Lahey Clinic (Boston), is based on a review of 400 cases. The procedure at that institution is as follows: radiographic examination of the colon is preceded by the administration of 1 1/2 to 2 ounces of castor oil the night before and a careful colonic irrigation on the morning of the examination. Following sigmoidoscopy, a routine barium enema study is made. If contrast air studies are indicated, these are performed at a separate examination, after a separate preparation of the colon. The author stresses the importance of the sigmoidoscopic study. In a series of 156 patients, 15 were found to have benign polyps within reach of the sigmoidoscope. In 10 of this number the polyps were not demonstrated radiologically.

In patients reporting for annual physical examination at the Lahey Clinic, sigmoidoscopic and radiographic examination of the colon is done every two years if no symptoms of colon or rectal disease are present. In those in whom polyps have been fulgurized, sigmoidoscopic examination is done at six weeks, three months, and six months, and annually thereafter.

The author discusses the treatment of rectal and colonic polyps and on the basis of his series of 400 cases seeks to answer the question: If a patient has a benign mucosal polyp of the rectum or colon and if this polyp is completely destroyed or removed, what are the chances of further polyps or malignant disease developing in these organs? In 6 per cent of the entire series, or in 8 per cent of the cases followed, polyps or cancer developed. Even though the follow-up is incomplete, there is sufficient evidence to indicate that all patients who have had polyps, and most certainly those who have had malignant disease of the colon and rectum, must be followed indefinitely. The ideal approach to the treatment of cancer of the colon and rectum is that of prevention. This can be realized by the detection



and removal or destruction of these tumors in their premalignant phase.

Two roentgenograms; 3 photographs

DONALD DE F. BAUER, M.D.  
Coos Bay, Ore.

#### **A Pedigree of Multiple Polyposis of the Colon.**

James V. Neel, Robert J. Bolt, and H. Marvin Pollard. *Gastroenterology* 26: 1-11, January 1954.

The authors have worked out in detail the pedigree of a family which showed a remarkable tendency to multiple polyposis of the colon. Sixteen persons in three generations were known to have polyposis and 6 others were probably affected. This study tended to show that the pattern of inheritance is that of a simple dominant trait with an approximate ratio of normal to affected offspring of 1:1. In none of the cases examined in the pedigree was there abnormal pigmentation of the lips, buccal mucosa, or skin of the mouth, fingers, or toes.

This dominantly inherited disease usually becomes of clinical importance in the thirties or forties, well along in the reproductive period of life. An affected person may thus have several to many children before the overt consequences of the inherited abnormality appear. It is possible, however, to detect with a high degree of accuracy individuals who have inherited the abnormal gene long before the onset of symptoms. Accurate advice can thus be given to a young man or woman concerning the chance that the defect will appear in his or her offspring. The patient can also be offered surgical measures for dealing with the disease in its premalignant stages in such a way as to decrease greatly the risk involved.

In a series of 32 patients in whom polyps had undergone malignant change, the mean age at which this change developed was 38.5 years. Nevertheless, any person with polyposis above the age of twenty-five is well within the danger zone. The most conservative approach to the problem is a subtotal colectomy with an ileosigmoidostomy, followed by periodic fulguration of the remaining polyps. While this undoubtedly lessens the possibility of cancer, experience has shown that usually sooner or later one of the remaining polyps becomes malignant. A more radical procedure, which has a better chance of removing further possibility of malignant change, is a complete colectomy with permanent ileostomy.

One roentgenogram; 2 photographs; 2 charts (including a pedigree of the family described).

WINSTON C. HOLMAN, M.D.  
Shreveport, La.

**Barium Granuloma of the Rectum. Report of a Case.** Harold L. Beddoe, Saul Kay, and Sidney Kaye. *J.A.M.A.* 154: 747-749, Feb. 27, 1954.

The authors report the excision of a barium granuloma from the rectal wall in a patient who had had several previous x-ray studies of the colon. Trauma incident to one of these examinations, unnoticed at the time, is believed to have allowed the escape of barium into the tissues. The barium suspension was then deposited within the submucosa, with subsequent healing of the mucosal defect and development of a foreign-body granuloma.

Four photomicrographs.

DONALD DE F. BAUER, M.D.  
Coos Bay, Ore.

**Roentgen Examination in Acute or Chronic Appendicitis.** Sv. A. Chrom and C. E. Gudbjerg. *Acta radiol.* 41: 132-140, February 1954.

This study is based upon the hypothesis that the pressure within the appendiceal lumen increases in acute appendicitis; that the appendiceal sphincter-like mechanism which is presumed to exist at the junction of the appendix and cecum contracts and prevents contrast medium from entering the appendix.

For their studies the authors used a barium meal mixed with a carboxymethylcellulose preparation. Roentgenograms were taken five, seven, ten, and twenty-four hours after ingestion of the contrast substance. In children, an additional examination was carried out as early as three hours. At each examination two films were taken, one with and one without compression.

The patients studied were divided into two groups. In Group 1, consisting of 70 patients, no operation was performed, and the observations of the investigators were evaluated in conjunction with the clinical diagnosis of their surgical associate. Thirty-one patients in this group showed complete appendiceal filling, and in 25 of this number some other diagnosis than appendicitis could be made. Of 23 patients with no filling of the appendix, 18 revealed definite clinical signs of acute appendicitis. The second group consisted of 20 cases in which surgery was performed, 10 acute and 10 chronic. In none of the 10 patients with acute appendicitis was contrast filling of the appendix seen. Six of the chronic cases showed partial filling and 4 no filling.

On this basis, the authors conclude that in acute appendicitis, the appendix fails to fill, whereas in the chronic variety one may see either partial filling, cicatricial strictures, or complete fixation.

Four roentgenograms; 4 tables; 1 graph.

RICHARD E. OTTOMAN, M.D.  
University of California, L. A.

**Duodenocolic Fistula Due to Acute Cholecystitis.** William E. Neville. *Am. J. Surg.* 87: 300-302, February 1954.

This is a report of a single case of duodenocolic fistula due to acute cholecystitis-cholelithiasis. The diagnosis was made roentgenologically following a barium enema, and multiple-stage surgery was successfully carried out.

The usual cause of a duodenal fistula is cancer of the transverse colon. Only 9 cases of benign origin were found in the literature. The majority of these were associated with duodenal ulcer. One was due to typhoid ulcer, 1 to ulcerative colitis, and 2 to tuberculous lymph nodes.

Two roentgenograms.

PAUL MASSIK, M.D.  
Quincy, Mass.

**The Case for Operative Cholangiography.** Charles D. Sherman, Jr., and Samuel J. Stabins. *Surg., Gynec. & Obst.* 98: 233-236, February 1954.

Even the most experienced surgeon, to his chagrin, has found at times that stones have been left in the common duct despite thorough exploration. Two cases requiring reoperation for common duct stones are described. It is believed that operative cholangiography would have prevented the need for a second operation.



The authors have seen no serious complication following operative cholangiography, though a mild febrile reaction has been encountered. They believe that the procedure is not widely done because of lack of experience in its use and in the interpretation of the films, combined with the initial difficulty in joint preparation by those directly concerned. Its use is urged in all cases in which exploration of the common duct is considered, as well as those in which it is actually explored.

Seven roentgenograms.

GEORGE R. KRAUSE, M.D.  
Mt. Sinai Hospital of Cleveland

**The Terminal Portion of the Common Bile Duct and of the Pancreatic Duct of Wirsung.** E. S. R. Hughes and R. H. Kernutt. *Australian & New Zealand J. Surg.* 23: 223-235, February 1954.

Thirty autopsy specimens, each including the duodenum, pancreas, and common bile duct, were studied and observations were made of the course of the bile and pancreatic ducts and the location of the duodenal papilla. The findings are discussed with regard to their clinical, radiological, and surgical significance.

Most confusion encountered in the interpretation of cholangiograms is in the identification of abnormalities at the lower end of the common bile duct. The shadow cast by the medium filling the common duct tapers abruptly at the lower end to continue as a slightly tortuous and narrow pathway into the duodenum. A normal abrupt narrowing of the distal, intramural end of the common duct should not be confused with stricture. The medium normally enters the duodenum without delay, and its presence here may increase the possibility of error by partly overlapping the terminal common duct shadow. In most instances gallstones appear as filling defects, and are to be found in that part of the common duct just proximal to the narrowed intramural segment. Very small stones may not be detected at all, although if the film is closely studied, their presence may be revealed by indentations on the edge of the shadow thrown by the bile duct just before it narrows. A very large stone impacted in this part of the duct prevents any filling of the lower duct and may be responsible for an abrupt concave termination of the duct shadow. A stone impacted in the intramural portion of the common duct interferes with the entry of the medium into the duodenum; it may obstruct the pancreatic duct by pressure on the thin V-shaped papillary septum which separates the two ducts near the ampulla. Pancreatic duct obstruction appears more likely to be a factor in pancreatitis than reflux up the duct. A T-tube placed through this area could also be responsible for pancreatic duct obstruction.

Seven roentgenograms; 5 photographs; 17 drawings.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

**Hydrops of the Gall Bladder in a Fourteen-Month-Old Infant.** Nathan M. Greenstein and Howard Weson. *Am. J. Dis. Child.* 87: 208-211, February 1954.

A case of hydrops of the gallbladder was observed in a fourteen-month-old infant, the youngest to have been reported with this condition. The child was asymptomatic, but a mass was palpable in the right upper quadrant of the abdomen. Roentgenographically this was seen to displace the transverse colon downward and

to the left. Perirenal air insufflation revealed normal kidneys and indicated that the soft-tissue mass was located anteriorly. The child recovered uneventfully after removal of a chronically inflamed gallbladder with a capacity of 4 ounces.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

**Roentgen Diagnosis of Pancreatic Diseases.** Carlos Coqui. *Rev. mex. de radiol.* 7: 371-374, October-December 1953. (In Spanish)

Roentgen diagnosis of pancreatic disease depends mostly on indirect evidence—extrinsic pressure on or invasion and displacement of the adjacent stomach, duodenum, and small and large intestine. For the diagnosis, therefore, co-operation between clinician and roentgenologist is essential, with a full consideration of the history and physical and laboratory findings.

The author discusses briefly the various roentgen signs. In tumors the Frostberg sign (inverted "3") and crowding of duodenal diverticula are most conspicuous. Cysts encroach upon adjacent organs and displace them. In pancreatic lithiasis the shape, grouping, and location of calculi are fairly characteristic. Abscesses, which are rare, may form gas pockets. Annular pancreas most frequently causes an hourglass constriction of the descending duodenum. Fibrosis and fibrocystic changes and congenital anomalies are briefly mentioned.

Eighteen roentgenograms accompany the paper. Most of these are of large cysts; others show an annular pancreas, the Frostberg sign in tumors of the head of the pancreas, stenosis of the duodenojejunal flexure due to aberrant pancreas, and stenosis of the papilla of Vater with marked dilatation of the common bile duct.

Eighteen roentgenograms. E. KRAFT, M.D.  
Newington, Conn.

**Acute Abdominal Syndrome Caused by Ascariasis.** Oriol Arango and Benjamin Perez-Mejia. *Rev. mex. de radiol.* 7: 337-351, July-August-September 1953. (In Spanish)

Ascariasis occurs very frequently in Colombia, not only in infants and children but also in adults. It can produce a multitude of manifestations, including acute gastrointestinal upsets, gallbladder disease, intestinal obstruction, anemia, eosinophilia, hemorrhage, endocrine and toxic nervous symptoms, as well as circulatory disturbances with hypotension and palpitation.

The author describes and illustrates 14 interesting cases in which the parasites were recovered from the stools by the dozens, hundreds, and even thousands, and were demonstrable roentgenographically throughout the gastrointestinal tract, including the appendix, gallbladder, and bile ducts. The worms caused acute intestinal hemorrhages and palpable masses and packed the small and large intestine in such numbers as to cause symptoms and signs of obstruction from the duodenum to the colon. In one case bleeding duodenal ulcer was suspected, but only ascarides were found in the stomach, duodenum, and small intestine. In another case cholecystectomy was attempted but, because of the numerous worms in the bile ducts and gallbladder, only cholecystostomy could be performed. In one instance the worms were recovered from a Meckel's diverticulum, and the patient died from necrosis of the diverticulum. In another case death was

due to intestinal obstruction with secondary gangrene of the cecum and appendix.

Twenty-four roentgenograms illustrate the interesting cases, which in the far-advanced stage can be considered most unusual, at least in the greater portion of the North American continent.

E. KRAFT, M.D.  
Newington, Conn.

### THE MUSCULOSKELETAL SYSTEM

**Infantile Cortical Hyperostosis. An Inquiry into the Etiology and Pathogenesis.** James B. Sidbury, Jr., and J. Buren Sidbury. *New England J. Med.* 250: 309-314, Feb. 25, 1954.

Infantile cortical hyperostosis is characterized by a usually sudden onset of swelling of the face, thorax, or extremities, hyperirritability, fever, a fluctuating course, and roentgenographic evidence of periosteal new-bone formation. Anemia, leukocytosis, and an elevated sedimentation rate are commonly present. The authors present 10 case reports.

This syndrome invariably begins in the first five months of life. The average age at onset is about nine weeks. The abnormality has been noted six hours after birth and cases have been diagnosed *in utero*. There is no set order of appearance of the symptoms. Generally speaking, the degree of febrile response and irritability may be correlated with the extent of bone involvement.

Although the condition can be suspected clinically, a definitive diagnosis is dependent upon the roentgenologic findings. The basic lesion is subperiosteal new-bone formation along the diaphysis of the bone. There is no roentgenographic evidence of involvement of the metaphysis or the epiphyseal centers of ossification. The early lesions may not be seen on the x-ray films or may be evidenced by a narrow margin of increased density beneath the periosteum that later thickens and becomes an obvious lesion characteristic of infantile cortical hyperostosis, with obvious elevation of the periosteum and piled-up periosteal new bone. In the later stages of the disease, the originally thickened bone may heal, with resorption from within, leaving an enlarged bone with a thin cortex and a large medullary cavity. Dentition has not been reported to be affected. Practically all bones have been involved except the vertebrae. Involvement is usually asymmetrical. The mandible is involved in 77 per cent; tibia, 44 per cent; ulna, 36 per cent; clavicle, 35 per cent; ribs, 32 per cent; humerus, 32 per cent; femur, 32 per cent; fibula, 18 per cent; pelvis, 6 per cent, and skull 3 per cent.

The average age before clearing of all signs and symptoms, as observed in 8 of the authors' cases followed long enough for determination of this point, was nine and a half months; for resolution of the x-ray evidence twenty-seven months was required. Residual deformity of the involved bones has been noted in some cases. The prognosis for life is excellent, but this syndrome is not so benign as it was formerly believed to be. There are 4 recorded deaths; 3 were due to infection, and in the other the cause was undetermined.

Although the exact etiology is not known, recent investigations seem to indicate that there may be an inherited defect in the arterioles supplying the affected areas. It is believed that the resultant local hypoxia produces edema and hyperplasia of the periosteum, which in turn results in over-production of imperfect

bone. Whereas hyperemia causes resorption of bone, diminution of the blood supply stimulates new bone production. The lesions are tender and painful when the proliferative process causes tension of the periosteum. The fever, the leukocytosis, and the elevation of the sedimentation rate are due in part to the tissue necrosis. The arterial intimal proliferation found in the overlying soft tissues is believed to be an inherited defect.

Two roentgenograms. ALFRED O. MILLER, M.D.  
Louisville, Ky.

**Roentgen Studies Regarding the Question of Congenital Rachitis.** W. Jung. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 181-185, February 1954. (In German)

From time to time cases of congenital rickets have been reported in the roentgen literature. In view of positive roentgenographic findings, histologic changes of active disease might have been expected, but such findings have never been observed in the newborn.

Because of this lack of histologic confirmation, the author studied a series of 150 newborn infants. He found occasional roentgenographic changes in distal radii and ulnae, but, strangely enough, only in healthy infants and not in the premature, debilitated, or malnourished. The abnormal findings proved to be due to faulty positioning, with resulting double contour and an occasional cupping effect of distal radii and ulnae. Whenever the examination was repeated with careful positioning so that the central roentgen beam was tangential to the metaphyseal end-plate of the long bones, the roentgen findings became normal.

Thus, the author disproves the existence of congenital rickets. He claims, also, that even the development of rachitis cannot be predicted on skeletal roentgenograms of the newborn.

Eight roentgenograms; 2 diagrams.  
E. KRAFT, M.D.  
Newington, Conn.

**So-called Growth Lines: Pathologic-Anatomical and Clinico-Roentgenologic Studies.** H. G. Wolf and L. Psenner. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 141-153, February 1954. (In German)

In 100 autopsies on newborn infants, roentgenographic and microscopic examinations were made of the long bones. In 18 cases pathologic changes were found: in 8 transverse zones of decreased density, in 5 zones of increased density (so-called growth lines), and in the remaining 5 a combination of the two. Death was due to various causes, but predominantly to stillbirth, immaturity, various infections of the respiratory and intestinal tracts and of the central nervous system, subtentorial hemorrhage, hemolytic icterus and blood dyscrasias. Syphilis and syphilitic osteochondritis were present in only 1 case.

The authors found that areas of decreased density in the metaphyses of long bones were non-specific. They were not characteristic of an early phase of syphilitic osteochondritis and failed to show any specific inflammatory tissue histologically. In zones of increased density or condensation, the histologic study revealed increased calcium deposits in the cartilaginous matrix, with decreased osteoblastic activity.

Various non-specific causes are believed to be responsible for the abnormal bone findings, but a syphi-

litic etiology has been disproved, and the diagnosis of early syphilitic osteochondritis on the basis of zones of decreased bone density is considered unreliable and incorrect.

Five roentgenograms; 4 photomicrographs; 1 table.

E. KRAFT, M.D.  
NEWINGTON, Conn.

**Dysplasia Epiphysialis Punctata. Report of a Case and Review of the Literature.** W. W. Frank and M. B. Denny. *J. Bone & Joint Surg.* 36-B: 118-122, February 1954.

The authors describe the radiologic and histologic findings in a full-term stillborn infant with punctate epiphysal dysplasia. Roentgenograms taken three and a half weeks before delivery disclosed a fetal abnormality, resembling achondroplasia. The stippling of the epiphyses could be seen at this stage, through the hydramnios. The most striking feature was the deformity of the limbs, which were short, thickened, and stubby, especially the left thigh and arm and the left foot. There were well marked flexion deformities of the right knee and left elbow and ulnar deviation at the left wrists.

In post-natal roentgenograms the sacrum and lumbar and lower thoracic vertebrae were represented almost entirely by opaque dots about a millimeter in diameter, mostly discrete but in places coalescing. The pelvic bones showed the same stippling, especially in the pubic rami and acetabulum. The alae of the iliac bones were well ossified, but the epiphyses of the iliac crests, which normally do not appear until thirteen to fifteen years, were present and stippled. The femora showed stippling at both proximal and distal epiphyses. The left femoral diaphysis was shortened, thickened and bowed, and showed a pseudo-fracture. The patella and all epiphyses of the tibiae were stippled. The tarsus appeared entirely in the form of calcified spots, bearing little resemblance to the normal anatomy. Stippling occurred only at the inferior angles of the scapulae, but the left glenoid was deformed. All the epiphyses of the arm and forearm were stippled. The left humerus, radius and ulna, like the left femur, had short, thick diaphyses, and the left radius was much bowed. The sternum consisted almost solely of punctate calcification, and the same appearance was seen in some of the costal cartilages. The hyoid bone and cricoid cartilage were entirely stippled. Faint stippling of the base of the skull appeared to be present.

Five roentgenograms; 1 photograph.

**An Unusual Lipoid Reticulosis of Bone.** Denis Burkitt and H. A. T. Fairbank. *J. Bone & Joint Surg.* 36-B: 109-113, February 1954.

The authors present the case of an eight-year-old boy with an affection of the skeleton not previously described. The patient was admitted to the hospital with a painful swelling of the left foot and leg. Ten months previously the distal phalanx of the left great toe had been amputated elsewhere for some septic condition. Two months later the left foot became painful and swollen, the swelling gradually spreading up toward the knee. There was no edema and no open or healed sinus. There was a slight rise in temperature over the affected area but no tenderness. Movement of the ankle joint was only slightly impaired. The affected leg was one inch longer than the other, measured

from knee to ankle. There was no enlargement of the spleen.

The entire skeleton was studied roentgenographically. The affected bones were examined again in six months and no significant change could be detected. The lesion involved the whole of the left tibia and fibula and all the bones of the foot. There was a small zone of abnormality in the left lower femoral epiphysis. The bones were irregularly expanded, their cortices were thin, in some places not detectable. The whole thickness of the bone was occupied by a core of fairly widely spaced coarse trabeculae in the normal line of the shaft, with spicules of trabeculation radiating perpendicularly from it and ending in a faint line of calcification marking the new boundary of the bone. The right humerus showed a cyst-like area in the middle of its shaft. The overlying bone was expanded, and its cortex thinned. Proximal and distal to the zone of rarefaction the original films showed coarse and thickened medullary trabeculation. There was no suggestion of "Erlenmeyer flask" deformity in the lower portions of the femoral shafts.

Histologic examination of tissue from the left tibia showed replacement of bone and marrow by vascular cellular tissue composed of fibroblasts, large, pale, rounded or polyhedral cells with granular or finely vacuolated cytoplasm, and a sprinkling of plasma cells, lymphocytes, and eosinophils. The large pale cells were conspicuous and probably contained lipid material; they were indistinguishable from Gaucher's cells. The humerus showed changes essentially the same as those in the tibia, though sheets of large pale "Gaucher" cells dominated the picture and the structure was more delicate and less fibroblastic.

The authors have encountered no other case, not even of the most widespread polyostotic fibrous dysplasia, which showed such complete and almost uniform changes in all the bones of the distal half of a limb; the profuseness of the changes appears to be unique. They believe this case must be regarded as one of the lipid reticuloses, possibly of the Gaucher type, although the absence of enlargement of the spleen is not in accord with this last diagnosis.

Seven roentgenograms; 2 photomicrographs; 1 photograph.

**Roentgen Evaluation of the Dynamics of Low Back Pain.** Paul S. Friedman. *Pennsylvania M. J.* 57: 143-147, February 1954.

This is a radiologist's interpretation of the causes of low back pain. There are three major spinal causes: (1) congenital anomalies, (2) postural malalignments, and (3) intervertebral disk abnormalities.

Of the *congenital anomalies*, spondylolysis is the most important. It is a defect in the pars interarticularis of a vertebra, most often L-5. The author claims that it is almost invariably accompanied by spondylolisthesis. [This is not the experience of the abstractor and his colleagues.] The defect is best seen in the oblique projection. Spondylolysis may also occur as a traumatic lesion. Less important congenital anomalies are: spina bifida; transitional vertebrae, often with degeneration of the regional intervertebral disks (either sacralization of L-5 or lumbarization of S-1); malalignment of the lumbosacral joints, *i.e.*, anteroposterior or transitional type instead of the theoretically normal external-internal type.

*Postural malalignments* are best studied in the erect

and recumbent positions. Sometimes sitting postural films are helpful. The anteroposterior films permit measurement of the lower extremity length, sacral obliquity, and lumbar scoliosis, and indicate the need of compensatory lift therapy. The lateral films demonstrate the lumbosacral angle (an angle greater than  $42^\circ$  predisposes to instability) and the degree of lumbar lordosis.

*Abnormality of the intervertebral disk* may be traumatic but is often associated with predisposing postural abnormalities. Roentgenograms may show narrowing of the disk space, apophyseal joint subluxation, air in the intervertebral disk space, exostoses on the anterior aspect of the vertebral bodies, retrodisplacement of a vertebra on that below it, and angulation-type scoliosis. Functional studies aid in making the diagnosis, since there are limited motion, parallel dislocation, and no increase in the lumbosacral angle in changing from the recumbent to the erect position.

Sacroiliac joint abnormalities are a less frequent cause of back pain. Other factors of significance are rheumatoid arthritis and excessive sacroiliac relaxation.

Eight roentgenograms. PAUL MASSIK, M.D.  
Quincy, Mass.

**Radiographic Bone Changes at the Hip After Insertion of an Acrylic Prosthesis.** St. J. D. Buxton and W. Waugh. *J. Bone & Joint Surg.* 36-B: 50-56, February 1954.

The authors describe the roentgen changes that take place in the upper end of the femur after the insertion of an acrylic prosthesis of the Judet type. Their paper is based on a series of 44 patients operated upon between May 1950 and April 1952. The primary condition was osteoarthritis in 29 patients, subcapital fracture in 8, avascular necrosis in 5, rheumatoid arthritis in 1, and congenital dislocation in 1. The average follow-up period was twenty months (longest thirty-two months, shortest twelve months).

*The Bony Channel in the Femoral Neck:* The first change seen after the operation is the development of a linear shadow which appears to outline the transradiant stem of the prosthesis. This consists of a condensation of bone trabeculae which may represent a healing reaction in the raw surfaces left by the reamer. In standard films in which the magnification is slight, when the diameter of the metal insert is known, measurements can be made which allow the width of the radiolucent plastic to be compared with the width of the bony channel. In most of the 33 cases in which this was done, the prosthesis was found lying in a bony channel several millimeters wider than itself. In arthrograms the contrast medium is frequently seen to have trickled down inside the femur around the stem. The width of the film of contrast medium does not correspond exactly with the space between the stem and the wall of the bony channel. A clear zone is sometimes apparent between the bone and the opaque material, suggesting that the bony channel is lined with a layer of soft tissue (up to 2 mm. thick). Therefore, direct comparison between the width of the stem and the diameter of the bony channel gives an exaggerated impression of the looseness of the prosthesis. Under these conditions, the prosthesis presses toward the lower border of the neck when weight is taken through the hip, and the metal insert comes to lie nearer the lower border of the bony channel than the upper. Roentgenograms of the hip in adduction and in abduction provided no evidence that the

prosthesis was able to rock within its apparently wide channel.

*The Stump of the Neck:* In most cases the cut edge of bone becomes smooth and rounded during the first year after the operation, thus conforming to the under-surface of the head of the prosthesis. When the prosthesis is in valgus, the upper and lower borders of the neck appear equally well developed. If the prosthesis has been placed in the neutral or varus position, there is usually sclerosis and sometimes obvious buttressing of the lower border.

*The Distal End of the Femur:* When the prosthesis reaches, but does not penetrate, the lateral cortex of the femur below the trochanter, obvious alterations in the normal bony structure take place. These are seen as early as six months after operation and are the consequence of weight-bearing. First, there is condensation of trabeculae below and around the stem, forming a triangle or ledge of bone, which undoubtedly helps to support the prosthesis. Secondly, subperiosteal new bone is frequently laid down on the lateral cortex opposite the end of the stem. These two reactions are frequently present, either separately or together, depending on the angle of insertion of the prosthesis.

*Acetabulum:* Radiographic changes develop only occasionally in the acetabulum. They are usually associated with a tendency to subluxation, when the weight-bearing surface is concentrated over a relatively small area.

The formation of bone in the soft tissues around the hip may occur after any form of arthroplasty. Only twice in the authors' series was it thought to be the cause of pain and limited movement. In 6 patients small fragments of bone were present, but they did not interfere with function.

Technical details of the operative procedure and their relation to the changes described above are discussed. Although the period of observation is short, it is suggested that after initial loosening the prosthesis becomes stabilized as a result of local bone reaction.

Eight roentgenograms; 1 drawing; 2 charts.

**Cough Fractures (Stress or Fatigue Fractures) of Ribs.** O. Starke. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 191-197, February 1954. (In German)

This is a discussion of cough fractures of the ribs seen within a period of six months, especially during an influenza epidemic. There were 15 cases, mostly associated with bronchial asthma, with a total of 35 fractures. In 8 cases only one rib was involved, in 7 cases multiple fractures were noted, in 5 on one side, in 2 bilaterally. The 5th, 6th, 7th, and 8th ribs were involved 24 times, the 9th, 10th, 11th, and 12th ribs 11 times.

Although the right ribs are said to be less often involved because of the underlying liver, which is believed to assure increased stability, in this series ribs on the right side were the site of fractures almost twice as frequently as left ribs. In 6 cases there were associated symptoms; 9 were asymptomatic. One case was complicated by hemothorax, which is believed to be rare in this type of fracture.

The author believes that a sudden pull is not responsible for these fractures but that they are fatigue fractures. Irregular areas of rarefaction and decreased bone density can usually be recognized at the fracture site, and even before the fracture occurs, when films of good quality are available. Tomograms are helpful in doubtful cases and for revealing abnormal bone texture.



Early recognition of cough fractures is important for prompt therapy and for the prevention of complications. Possibility of medicolegal claims at a later date is also mentioned, if the fractures do not receive prompt attention.

Nine roentgenograms.

E. KRAFT, M.D.  
Newington, Conn.

**Pubic and Ischial Necrosis Following Cystostomy and Prostatectomy (Osteitis Pubis).** Edwin L. Lane and Hon Chong Chang. *Am. J. Roentgenol.* 71: 193-211, February 1954.

The authors add 9 cases of osteitis pubis incident to cystostomy and prostatectomy to the 120 cases previously appearing in the literature, and make special reference to early diagnosis and roentgen therapy.

The onset is usually abrupt, two to twelve weeks after prostatectomy, with severe pain in the pubic, perineal, or inguinal area. There may be associated fever, low to moderate, a leukocytosis, and increased sedimentation rate.

Two to four weeks are commonly required for the first roentgen evidence of erosion to appear. For the demonstration of these early changes, a small film, a long narrow cone, a 1.0-mm. focal spot, and a suitable range of contrasts (preferably a high and a low) are necessary. With these, a small, isolated area of cortical erosion will be apparent. This gradually progresses to an irregular and ragged destructive lesion extending over several inches but confined to a depth of 1 to 5 mm., never transecting bone and rarely creating a sequestrum. The bilaterality and symmetry of the involvement are characteristic. In two to twelve months the roentgenogram shows the stage of repair, new periosteal and cortical bone appearing, with slight to severe distortion at the sites of former erosion. Clinical improvement is almost always far ahead of the roentgen evidence of repair. Occasionally there is a persistent arthritis of one or both hips.

Osteitis pubis has been attributed to trauma to the bone, periosteum, vessels, or nerves, to a combination of trauma and infection, and to infection alone. The authors believe that infection is at least one of the causative factors.

All the patients in the present series received x-ray therapy, with small divided doses stopping before bone repair was complete. The usual effect was prompt partial relief within a few days, followed by a period of weeks or several months with symptoms of decreasing and irregular quality. The average total duration of symptoms for the 8 cases was 8.3 months.

Twenty-eight roentgenograms; 3 drawings; 1 table.

I. MESCHAN, M.D.  
University of Arkansas

**Osteochondritis of the Superior Tibial Epiphysis.** J. L. Boldero and G. P. Mitchell. *J. Bone & Joint Surg.* 36-B: 114-115, February 1954.

The authors report a case of osteochondritis of the superior tibial epiphysis in a twelve-year-old boy, the first such case to be recorded. When first seen, the patient complained of pain in the right knee of three months duration. Physical and roentgen examinations were normal. Three months later local swelling and slight increase in heat and tenderness over the lateral tibial condyle developed, and roentgenograms showed evidence of increased density of the tibial epiphysis.

Epiphysal density increased further over the next few months. Within a year of first symptoms, the knee appeared quiescent; roentgenograms showed advanced revascularization.

The clinical course and the radiographic findings of sclerosis followed by resorption and satisfactory reorganization one year later suggest that this condition might be classed as an osteochondritis of the superior tibial epiphysis.

Five roentgenograms.

**The March Fracture Persists. A Report on 145 Cases During a Fifteen-Month Period at an Infantry Basic Training Center.** W. Todd DeVan and Donald C. Carlton. *Am. J. Surg.* 87: 227-231, February 1954.

March fractures are stress fractures of the metatarsal bones occurring in poorly conditioned feet subjected to long and unusual exertion, especially long marches. The incidence reaches a peak around the tenth week of basic military training, which corresponds to the periods of lengthy speed marches and vigorous mountain climbing. The onset is usually insidious. At first, the roentgenogram reveals a minimal fracture of the shaft of the metatarsal, without displacement. With healing, there is excessive callus formation.

The authors report a series of 148 march fractures in 142 patients, treated over a fifteen-month period with very satisfactory results. These included 55 fractures of the second metatarsal, 80 of the third, 10 of the fourth, and 3 of the fifth. Only 5 of the patients were Negroes, a proportion much lower than that of Negro to white troops. The presence of flatfoot, short toes, and other abnormalities had no bearing on the incidence.

Treatment consisted of application of a short leg plaster-of-Paris cast with a walking iron or plaster heel. The foot is immobilized three weeks for a fracture of the fourth or fifth metatarsal, and four weeks for the second or third. After the removal of the cast, physiotherapy and foot strengthening exercises are given. The average disability time was 34.5 days.

Three roentgenograms; 2 photographs.

PAUL MASSIK, M.D.  
Quincy, Mass.

**Radiologic Findings in Injuries of the Fingers.** Erling Kierulf. *Acta radiol.* 41: 163-168, February 1954.

Roentgen studies of interphalangeal or metacarpophalangeal joint distortions or contusions made some time after injury may show juxta-articular bone lesions. Often these present an appearance similar to the punched-out defects seen in gout.

The author reports his findings in a series of 20 patients seen over a period of several years. No osseous changes were demonstrable immediately after injury. Later, punched-out defects became apparent. The length of time necessary for these bone defects to appear roentgenographically is not known. Their etiology is not clear, but it is postulated that some degree of vascular disturbance may have occurred at the time of injury. This could result in localized ischemia which, if severe enough, might cause necrosis in that section of the bone.

The defects correspond to the capsular or the ligamentous insertion areas.

Eighteen roentgenograms; 1 drawing.

RICHARD E. OTTOMAN, M.D.  
Los Angeles, Calif.



**An Additional Case of Acro-Osteolysis with Differential Diagnosis.** U. J. Wassner. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 186-191, February 1954. (In German)

In a sixty-year-old man seen for a minor injury, the fingers were found to be blunted, the toes shortened, and the nails atrophied. The clavicles were described as "floating."

Roentgenographic study revealed symmetrical bone changes of the distal phalanges of the fingers and toes, with more or less complete disappearance of some of these bones. Of interest also were marked decalcification and "melting away" of the medial and lateral portions of both clavicles. The mouth was edentulous, and there was complete regression of the alveolar processes. Later on, decalcification and rarefaction developed in some of the ribs, but there was no generalized osteoporosis.

No clinical or laboratory evidence of pituitary dysfunction or of hyperparathyroidism was found, and a therapeutic test with large doses of vitamin D was unsuccessful. Surgical exploration of the neck revealed small parathyroid glands and a small thyroid, in spite of an increased basal metabolism rate (+30 to +50 per cent).

Of special interest was a history of gastric resection at the age of forty-three because of an ulcer. At forty-five the patient lost all his teeth and ten years later retired from work because of increasing weakness, loss of energy, and generalized pains, especially in thighs and below the ribs. He appeared undernourished; his skin was leathery and wrinkled, showing brownish pigmentation. There were dyspnea and tachycardia without cardiac or circulatory failure. The non-protein nitrogen was 48 mg. per cent. Gastrointestinal study revealed absence of free hydrochloric acid and of a histamin reaction. Rapid emptying of the barium-filled gastric pouch and of the jejunum was observed.

In view of these findings, the case was recognized as a state of acidosis due to starvation, with secondary hunger osteopathy due to greatly diminished food absorption in the jejunum.

On a diet rich in vitamins, calcium, and phosphorus, the body weight increased 8 kg. in six weeks, the basal metabolism rate became normal and the non-protein nitrogen decreased to 36 mg. per cent. After three months the patient had regained sufficient strength to help with farmwork. Follow-up studies of the bones were not obtained.

The author believes that identical bone changes can be caused by primary and secondary hyperparathyroidism. Although he calls the symmetric bone lesions at the tips of upper and lower extremities acro-osteolysis, he feels that a pituitary disturbance plays no role in the disease.

Five roentgenograms; 2 photographs.

E. KRAFT, M.D.  
Newington, Conn.

### HERNIA

**Diaphragmatic Hernia. Review of the Literature with Report of Illustrative Cases.** Robert T. Gants. *Ann. Surg.* 139: 166-178, February 1954.

The author has used Harrington's classification of diaphragmatic hernia (*Surg., Gynec. & Obst.* 86: 735, 1948) into non-traumatic and traumatic forms. The former are subdivided into the congenital and post-

natal types. Included in the last named group are the commonly occurring esophageal hiatal hernias. Three forms are recognized, the paraesophageal, the sliding, and the composite or double type. In the paraesophageal type, despite the fundal herniation, the cardia remains below the diaphragm. In the sliding type, however, the esophagus enters the stomach above the diaphragm so that gastric reflux is facilitated. The composite hernia combines features of both, usually representing a paraesophageal hernia that has become so relaxed that the cardia comes to lie above the diaphragm.

Characteristic symptom complexes for each type of hernia are described. In the sliding hernias the symptoms are those of esophagitis secondary to gastric reflux, and the size of the hernia need not be of significance. The symptoms of paraesophageal hernias, on the other hand, are due to mechanical obstruction and its secondary effects. Hematemesis and melena are common symptoms in both types.

Therapy in those cases which are symptomatic is predominantly surgical. The ideal procedure consists of reduction of the hernia, elimination of the sac, and repair of the defect. Most surgeons prefer the thoracic approach, and phrenic crush as an adjuvant measure is performed by many.

A brief discussion of the various forms of congenital and traumatic hernias is presented. Although the former group may be asymptomatic and found incidentally, they should be repaired to prevent such complications as incarceration, volvulus, or strangulation. Congenital absence of a leaf of the diaphragm in the newborn requires immediate surgical repair to prevent death. Traumatic hernias commonly occur at a considerable time after injury, since the defect may be temporarily sealed by omentum, with herniation only after some bout of increased intra-abdominal pressure.

Ten case histories are presented, depicting various types of diaphragmatic hernia. Roentgenograms accompany the case reports. Symptomatic and therapeutic correlations are stressed.

Eleven roentgenograms.

GEORGE E. LERNER, M.D.  
Cleveland City Hospital

**Hiatus Hernia as a Problem of Differential Diagnosis.** E. Hafer. *Schweiz. med. Wchnschr.* 84: 266-270, Feb. 27, 1954. (In German)

For roentgen demonstration of hiatus hernia, the author considers the Trendelenburg position not simple enough to be used routinely. For practical purposes he regards the right anterior oblique view on the horizontal table equally dependable. For a reversible hiatus hernia he has found the supine view with compression of the epigastrium still more revealing. With his simplified technic, he has recently discovered this condition eight times more frequently than in former years.

A hernia must not be confused with the esophageal ampulla. The latter is very often seen on deep inspiration but disappears on expiration. For this reason, exposures should always be made in expiration. The hernial sac is asymmetric and shows indentation of its lower border. Broad gastric rugae extend upward to the hernia in contradistinction to the slender folds of the esophagus and of the ampulla.

The author's series of 55 cases showed no sex predominance. Symptoms are characteristic, but not pathognomonic, depending frequently on certain body

positions. Pain usually occurs in a recumbent position following a meal, but will disappear with change to the erect posture. The pain, when retrosternal, may simulate a cardiac disorder. Small sliding herniae may cause marked discomfort, while large paraesophageal herniae frequently remain asymptomatic. Dysphagia is found in 33 per cent of cases; underlying disease, chiefly cholecystitis and duodenal ulcer, in 60 per cent; ulcer in the hernial sac in 30 per cent; hypochromic anemia in 25 per cent.

Reflux esophagitis must be excluded with the esophagoscope; if it is present, surgical repair is indicated to prevent development of an esophageal stricture.

Eight roentgenograms; 2 tables.

E. KRAFT, M.D.  
Newington, Conn.

**Transmesenteric Hernia in Infant. Report of Case Producing Jejunal Obstruction.** Peter W. Stone. *Ann. Surg.* 139: 244-247, February 1954.

The author presents a case of jejunal obstruction following prolapse of a loop of jejunum through a 3 X 2-cm. defect in the mid-portion of the jejunal mesentery in a seventeen-day-old white male infant. Transmesenteric hernia is an infrequent cause of intestinal obstruction, and diagnosis preoperatively in the infant is difficult. Differentiation must be made from hypertrophic pyloric stenosis, congenital stenosis or atresia, annular pancreas, malrotation of the small intestine with partial or complete volvulus, and duplications (enterogenous cyst). Roentgenography may sometimes reveal the approximate level of obstruction.

The recognized sites of intra-abdominal hernia are as follows: (1) Mesentericoparietal (paraduodenal) hernias occur at the duodenojejunal junction and are the result of a defect in the root of the mesentery. (2) Transmesenteric hernias occur more frequently through the mesentery of the terminal ileum, although the case presented is an example of a herniation high in the mesentery of the small bowel. (3) Ascending mesocolic hernia is the type in which the small intestine herniates laterally through a developmental defect in the ascending mesocolon. Less common types of true intra-abdominal hernia are hernia into the lesser peritoneal sac through the foramen of Winslow, hernia through an ommental defect, and, in the female, a hernia through the broad ligament.

One roentgenogram. BENJAMIN KAUFMAN, M.D.  
Cleveland City Hospital

**An Unusual Case of Bilateral Diaphragmatic Hernia in an Infant.** Paul F. Hausmann and Robert K. Salter. *J. Thoracic Surg.* 27: 190-196, February 1954.

The authors present the case of a four-months-old infant with an esophageal hiatus hernia of the short esophagus type through a defect in the right hemidiaphragm and a traumatic diaphragmatic hernia on the left, containing colon. The traumatic hernia had been produced at another institution when an attempt was made to correct the esophageal hiatus hernia from the left side. The two separate herniations were demonstrated on fluoroscopy and by roentgenograms. Since the symptoms were believed to be due for the most part to the incarceration of the colon in the traumatic hernia, the left-sided defect was repaired first. At a later date, repair of the right-sided hernia was undertaken because of persistent regurgitation and inability to retain a normal volume at one feeding. Follow-up studies

showed both the colon and the stomach below the diaphragm, with slight dilatation of the esophagus above the diaphragm.

The authors stress the advantages of the transthoracic approach and the importance of careful radiographic studies.

Nine roentgenograms. RENE FORTIER, M.D.  
St. Paul, Minn.

## GYNECOLOGY AND OBSTETRICS

**Roentgenographic Localization of the Placenta with a Plain Film.** Laura Fariñas and Rafael Gomez Zaldivar. *Rev. mex. de radiol.* 7: 380-383, October-December 1953. (In Spanish)

For localization of the placenta, the authors take a lateral view of the abdomen with soft-tissue technic, using a rotating anode tube, 50 to 60 kv.p., 100 ma., 36 inches distance, and grid. The placenta usually occupies one third of the surface of the uterus and appears as a crescent-shaped thickening at the inner wall of the uterine cavity. Visualization is sometimes impaired by hydramnios and by unusual stretching with associated thinning and confusing soft-tissue masses, as fibroid tumors. On the other hand, calcium deposits are sometimes observed which are helpful for proper localization of the placenta.

A posterior location of the placenta in the upper uterine segment is more frequent than an anterior location. Insertion of the placenta in the lower uterine segment will make its visualization difficult, but in case of marginal implantation it will cause a shift of the fetal head in the sagittal as well as the horizontal direction.

In transverse and breech presentations, evaluation of a low implantation may prove difficult. The authors have occasionally injected umbilical veins with contrast material after delivery and after severing of the umbilical cord but prior to separation of the placenta. With the help of this technic, they have succeeded in checking the accuracy of localization of the placenta.

Thirty-three roentgenograms. E. KRAFT, M.D.  
Newington, Conn.

## THE GENITOURINARY SYSTEM

**Artificial Nephrography by Combined Retrograde and Intravenous Urography. Preliminary Report.** Francis A. Herzan. *Am. J. Roentgenol.* 71: 228-234, February 1954.

A brief review of previous and present methods of artificial nephrography is presented, and a new technic, combining the retrograde and intravenous approach, is described. After completion of retrograde pyelography with the largest possible ureteral catheter, the latter is left in place with its free end clamped, acting as an artificial ureteral obstruction to prevent escape of contrast medium from the renal pelvis and calyces. Diodrast or other routinely used contrast material is then injected, and films are obtained at intervals of fifteen, twenty-five, and thirty-five minutes, until optimum saturation of the kidney tissue has been obtained. Since the saturation of the kidney remains constant until the retrograde contrast substance is released, as many films as are required may be obtained at a sitting, including laminagrams. The procedure should be performed on but one kidney at a time.

The advantages of this method are discussed and its applicability is demonstrated by a case presentation.

The possibility of crystallization of the medium within the kidney tubules in cases with elevated non-protein nitrogen should be kept in mind.

Eleven roentgenograms. NEIL E. CROW, M.D.  
University of Arkansas

**Nephrotomography. A Preliminary Report.** John A. Evans, William Dubilier, Jr., and James C. Monteith. *Am. J. Roentgenol.* 71: 213-223, February 1954.

Nephrotomography is the term applied to a technic in which body-section roentgenography is combined with intravenous cavitory nephrography to permit recognition of areas of non-functioning or malfunctioning renal parenchyma such as occur in cysts and neoplasms.

Preliminary plain films and tomograms are first obtained to serve as control studies and to check the roentgenographic technic. A 12-gauge Robb-Steinberg angiocardigraphic needle is inserted into an antecubital vein and, with the roentgen tube in mid-position, 50 c.c. of Urokon Sodium, 70 per cent, is rapidly injected into the abducted arm. A film is then exposed at the predetermined circulation time. The first film will demonstrate the renal arteries. This is followed as rapidly as possible by a second film, which secures the nephrogram. Immediately after this, a tomogram is obtained. The elapsed time between the first exposure and the completion of the tomogram should not exceed twenty-five seconds.

Preliminary results of this procedure in 20 cases are encouraging and a subsequent report is promised.

Excellent illustrations show retrograde pyelograms, arteriograms, nephrograms, and nephrotomograms defining masses and differentiating cysts and neoplasms of the kidney

K. EGNER, M.D.  
University of Arkansas

**On Renal Neoplasms Seen in Pneumoretroperitoneum.** R. Haubrich. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 242-249, February 1954. (In German)

Pneumoretroperitoneum, especially when combined with tomography, is of distinct value in the diagnosis of small renal tumors when ordinary studies are equivocal. In larger tumors, the method helps to determine the extent and character of the growth.

When the air surrounds the tumor, a malignant neoplasm can be safely excluded and a benign process, most likely a cystic lesion, may be suspected. Air coating will also be possible when a hemorrhage occurs within the renal capsule, but not in perinephritis or when a hematoma extends retroperitoneally outside of the kidney capsule. In carcinoma, soft-tissue masses are seen to cross the surrounding air.

Six cases are reported, including 1 of benign cysts, in which the air surrounded the kidneys. Of 3 carcinoma cases, 1 showed soft-tissue crossing of the air coating, the second an interruption of the air mass, and the third complete absence of air on the involved side. In a case of large hydronephrotic kidney one year after trauma causing hemorrhage within the capsule, the mass was surrounded by a thin layer of air. In the sixth case, a traumatic subrenal hematoma causing compression of the left upper ureter and slight secondary hydronephrosis, air coating was not accomplished, because of extensive perinephritis.

Eleven roentgenograms. E. KRAFT, M.D.  
Newington, Conn.

**Contribution to the Diagnosis of Papilloma of the Kidney Pelvis.** W. Schoenheinz and R. Frauboes. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 249-258, February 1954. (In German)

Primary tumors of the kidney pelvis are said to constitute 2 to 4 per cent of all renal neoplasms. During a three-year period, however, the authors found 10 neoplasms of the renal pelvis (26 per cent) in a total of 39 kidney tumors. Nine were papillomas and 1 a solid carcinoma.

Benign tumors of the renal pelvis exhibit a tendency to malignant change, and the five-year survival rate following operation is only 52 per cent. Multiplicity of lesions with downward spread to the ureterovesical junction has been observed; therefore, the ureter must be checked throughout its length and in all positive cases must be removed down to the bladder. In the presence of bladder papillomas near the ostia, a pyelogram is necessary to rule out papillomatosis originating in the kidney pelvis.

Roentgenologically, papillomas are recognized as filling defects with a fringe-like border in an eccentrically dilated kidney pelvis. In view of the unfavorable prognosis, an early diagnosis is essential and a plea is made for pyeloscopy during intravenous and retrograde pyelography in all borderline cases.

Six cases are reported, in 3 of which pyeloscopy with spot films established the diagnosis. Oblique views were also helpful in the demonstration of either a broad base or a pedicle.

In the differential diagnosis, radiolucent calculi, blood coagula, fibrin, and parenchymal tumors with extension to the renal pelvis must be ruled out.

Fourteen roentgenograms; 5 photographs.

E. KRAFT, M.D.  
Newington, Conn.

**Megaureter.** F. Douglas Stephens. *Australian & New Zealand J. Surg.* 23: 197-205, February 1954.

This paper is concerned with those cases of megaureter without demonstrable localized ureterovesical stricture or obvious neuropathic causes. Micturition cysto-urethrography serves to divide these into two types: those that permit vesico-ureteral reflux and those that do not. Thirteen cases of the former and 3 of the latter type were studied.

In the group with reflux, cysto-urethrography showed complete emptying of the bladder, bilateral incompetence of the ureterovesical junctions, and a filling defect in the iodide column at the junction. The more patulous the ureteric orifice, the more free was the reflux. Following micturition the ureters emptied rapidly into the bladder. They were completely empty after three successive acts of micturition at intervals of two minutes, so-called "triple micturition."

In the presence of megaureter without reflux there was marked delay in emptying of the ureters after retrograde ureterography, suggesting an obstructive etiology.

Recurrent urinary infections were the most common clinical manifestations in the reflux group. In the 3 cases without reflux there were hematuria and loin pain.

Treatment of the reflux group was selective chemotherapy and "triple micturition" to remove residual urine returning to the bladder after the reflux during the initial micturition. This should be done at frequent intervals to prevent reflux due to distention of the

bladder. All patients improved dramatically under this regimen.

Ten roentgenograms; 1 chart.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

### TECHNIC

**The Use of Hydrogen Peroxide for the Elimination of Gas from the Intestine During Roentgenography of the Abdominal Viscera.** Antonio Govoni, James F. Brailsford, and Eric H. Mucklow. *Am. J. Roentgenol.* 71: 235-238, February 1954.

Gas in the intestine is a source of annoyance in roentgenography of the abdominal viscera because it often obscures important outlines and details. Several suggestions have been brought forward to explain its presence. The most important are: (1) swallowing of air; (2) intestinal respiration, or interchange of gas between the blood and the interior of the intestine; (3) fermentation of intestinal contents.

To eliminate this undesirable gas, the authors use hydrogen peroxide in the preparatory enema, adding 10 c.c. to each liter of water. Good results have also been obtained with as little as 25 minims of  $H_2O_2$  per pint of water. The hydrogen peroxide may act by producing a neuromuscular excitation of the colon which stimulates evacuation and perhaps to a minor extent by increasing the tension of the colon, leading to a more rapid transfer of the gas to the blood stream.

The authors also advocate the use of hydrogen peroxide in the concentration suggested in the barium sulfate mixture used in examination of the colon. With it, effective evacuation of the bowel and a very good mucosal pattern of the whole colon is obtained.

Eight roentgenograms. J. R. MORRISON, M.D.  
University of Arkansas

**Comparison of Different Types of X-Ray Films for Case Finding and Diagnosis of Silicosis.** D. O. Shiels and D. L. G. Thomas. *M. J. Australia* 1: 200-204, Feb. 6, 1954.

Between 60 and 70 persons were submitted to examination with (a) 35-mm. film, (b) 70-mm. film, (c) non-screen 14 × 17-inch film, and (d) regular 14 × 17-inch screen film. Photoelectric timing was used for the 35- and 70-mm. studies.

Each set of films was examined by five radiologists, with an interval of several weeks between the sets. All the radiologists had had many years of general experi-

ence, and some had considerable experience in reading 35-mm. films, but none had intensive training or experience in reading industrial chest x-ray films of persons with silicosis or pneumoconiosis.

The survey showed the 14 × 17-inch unscreened films to be superior for detecting silicosis. The observers had no knowledge of the medical or occupational histories of the subjects.

Five graphs; 6 tables.

DONALD DE F. BAUER, M.D.  
Coos Bay, Ore.

**Use of Cortisone by Mouth in Prevention and Therapy of Severe Iodism.** William H. Waugh. *Arch. Int. Med.* 93: 299-303, February 1954.

Because of the favorable effects of cortisone in preventing severe iodism in a patient who had previously shown a marked iodide idiosyncrasy, the author suggests the possibility of administering cortisone prophylactically when roentgenography with iodized media is desirable in allergic individuals.

In an Addendum, mention is made of a recent report of a similar favorable effect of ACTH (Park, Cronk, and Cronk; *Dis. of Chest* 24: 219, 1953. *Abst. in Radiology* 62: 894, 1954).

Six photographs.

**Film Identification.** Robert D. Moreton and John R. Winston. *South. M. J.* 47: 124-128, February 1954.

The authors review the various means of film identification currently employed by some 50 radiologic groups. Their interest apparently began with a fear of embarrassment in medicolegal cases by errors in film identification.

At the present time the authors routinely employ lead numbers during exposure of the film to indicate the date and the patient's x-ray number. In addition, they use an identification card showing the name and location of their radiological group, and the patient's number, typed name, and signature. This information is used for direct printing at the time of processing. The signature card is then returned to the patient for disposal.

By using this double method of identification the authors feel they are able to reduce the number of errors which might occur and to discover earlier those which do occur.

Seven illustrations, including 1 roentgenogram.

RICHARD E. OTTOMAN, M.D.  
University of California, L. A.

### RADIOTHERAPY

**Combined Roentgen and Chemotherapy in Carcinoma.** J. G. Soba. *Rev. mex. de radiol.* 7: 330-336, July-August-September 1953. (In Spanish)

Since 1947, the author has used penicillin and other antibiotics in combination with deep roentgen therapy of carcinoma, for the control of associated infections. More recently he has tried the folic acid antagonist aminopterin in 5 cases of far advanced cancer treated by irradiation. After an initial aggravation of symptoms lasting five to six days, the patients took a remarkable turn for the better, with relief and gradual disappearance of pain. No details of treatment, however, are given in this preliminary report.

Four chest cases are briefly reported and illustrated, 2 bronchogenic tumors, 1 pulmonary metastatic process from mammary carcinoma, and 1 lymphosarcoma. The combined therapy was strictly palliative, but the immediate beneficial results were dramatic, as evidenced by follow-up roentgenograms.

Thirteen roentgenograms. E. KRAFT, M.D.  
Newington, Conn.

**The Question of Adequate Dosage in Malignant Tumors.** H. Chantraine. *Strahlentherapie* 93: 400-403, 1954. (In German)

It is generally accepted that an adequate cancerocidal



dose is at least 4,000 r in four or five weeks; 5,000 to 6,000 r is better; 2,500 r is rarely effective. It is regrettable that many physicians, principally non-specialists, administer systematically too small a tumor dose. It is estimated that about 50 per cent of malignant neoplasms are inadequately treated. This is the result either of ignorance or an attempt to avoid possible medicolegal responsibility for radiation reactions and damage of healthy tissue. It is true that an adequate radiation dosage involves the risk of unpopular reactions and injury to uninvolved tissues, but underdosage is a useless and unconscientious procedure having no curative value. It should properly be regarded as malpractice.

The principle of convenience—*primum nil nocere*—should be replaced by the principle, *salus aegroti suprema lex*, or "the interest of the patient is the highest law."

LEWIS L. HAAS, M.D.  
University of Illinois

#### Radiation Therapy of Some Dermatologic Disorders.

Anthony C. Cipollaro. New England J. Med. 250: 193-196, Feb. 4, 1954.

The ionizing radiations employed most commonly in dermatology are roentgen rays. Radium is used far less frequently than x-rays and almost exclusively for cavernous hemangiomas and epitheliomas. Only a few dermatologists employ radium needles interstitially for the treatment of cutaneous neoplasms. The radioactive isotopes have not, as yet, been found of great value by either surface or internal application in the treatment of skin diseases.

Many diseases of the skin respond favorably to superficial roentgen therapy. The author discusses a few illustrative conditions.

For acne showing a tendency to rapid spread and leaving deep pits and scars, x-ray therapy is recommended. The patient is treated each week, receiving up to a maximum of 16 treatments in a period of twenty-four weeks. If, as occasionally happens, an erythema develops after two or three treatments, applications are stopped, and resumed when the reaction subsides if indications still warrant. Unfiltered rays with a h.v.l. between 0.5 and 0.75 mm. of aluminum with a dosage of 75 r to each side of the face are used.

Controversy exists regarding x-ray treatment for symptomatic relief of neurodermatitis, psoriasis, lichen planus, and pruritus. Routine treatment is contraindicated. Particularly severe attacks may be terminated by application of a few weekly fractional doses. Careful records should ensure that only four to six treatments are given in any one area in any one year, but courses of four to six yearly treatments can be repeated for at least eight years without causing injuries. No one area receives more than 75 r at a treatment.

The greatest field of usefulness of x-rays in dermatology is in the treatment of lymphomas, such as mycosis fungoides and leukemia cutis. The cutaneous nodules respond well to irradiation. When nodules are scattered, it is necessary to divide the body into thirds and treat a third every other day, with a dose of 75 to 100 r. When the nodules are large or few in number, a single dose of 200 to 300 r once every two weeks to each closely shielded lesion is sufficient. For mycosis fungoides, nitrogen mustard, tartar emetic and radiophosphorus are inferior to x-rays and more hazardous.

For ordinary basal-cell epitheliomas 0.5 to 1.0 cm. in diameter, superficial roentgen rays with a h.v.l. of 0.75 mm. Al are recommended, in doses of 600 r every other day for seven treatments. For larger lesions of this type, a smaller dose of harder rays suffices. For squamous-cell epitheliomas, the dose is 5,000 or 5,500 r given over three weeks.

DONALD DE F. BAUER, M.D.  
Coos Bay, Ore.

#### Problems of Skin Carcinoma. August Poth. Strahlentherapie 93: 349-380, 1954. (In German)

This is a statistical survey of the cases of skin carcinoma which were treated by x-rays at the University of Frankfurt am Main between 1928 and 1951. The series includes 1,124 lesions in 860 patients (456 males and 404 females), of whom 46.4 per cent originated from rural areas and 53.6 per cent from urban populations. Multiple skin cancers occurred in 14.9 per cent of the patients. Of this latter group, 62.5 per cent came from rural and 37.5 per cent from urban populations. This indicates the etiologic role of rural occupations in the development of multiple precancerous and cancerous skin lesions. Ninety-three per cent of the lesions were found on the head.

The diagnosis was usually made clinically. Biopsy was not performed systematically. Data concerning five-year cures could not be collected. As a criterion of radiation effect, absence of recurrence in one year was selected.

Different techniques were used for irradiation. Chaoul or Müller contact therapy was preferred, resulting equally in about 92 per cent one-year cures. Treatment was given at one- to two-day intervals, the daily dose decreasing from 1,000 r to 400 r. When doses of 400 to 500 r were administered with longer (three to seven days) intervals, the results were poorer (43.8 per cent cures). For carcinomas over 5 cm. in diameter, treatment was given at 180 kv., with individual doses of 500 to 600 r. The results were less satisfactory than in smaller lesions. The best results were obtained with total doses of 6,000 r or more. The cure rates decreased proportionately with decrease of the total dose.

Metastases developed in the regional nodes in 32 cases. One patient died as a result of cerebral invasion. No distant metastases occurred. Larger lesions were found to metastasize more frequently than smaller ones. Prognosis of the metastases is poor.

As to the etiology, several skin disorders played a definite role: lupus vulgaris in 12 cases, other chronic skin diseases in 4, industrial skin damage in 2, radiation damage in 6, burns in 8, and acute or chronic traumatic skin damage in 17 cases.

Twelve photographs; 5 graphs; 20 tables.

LEWIS L. HAAS, M.D.  
University of Illinois

#### Epithelioma of the Cheek. J. Ernest Breed. Rev. mex. de radiol. 7: 310-321, July-August-September 1953. (In both English and Spanish)

Carcinoma of the cheek is best treated with radium or a combination of roentgen rays and radium. The author emphasizes the importance of preserving the tumor bed. To treat buccal carcinoma only with external radiation is obviously inadvisable, as the tumor bed would then receive a greater dosage than the tumor. When the tumor thickness is more than 1.0 cm., however, it is essential to deliver part of the total tumor



dose from the skin surface. Low-intensity radium needles are preferable for this purpose. When the growth extends backward to the angle of the jaw, radon seeds are necessary, as the application of needles would be too difficult.

The author prepares a circular radon applicator so that it will contain 400 to 800 mc. of radon filtered through 2 mm. of silver and 4 mm. of rubber. The applicator is held by hand against the tumor by means of a long rod, with the operator standing behind a large lead plate  $2\frac{1}{2}$  inches thick. The applicator is held for five minutes against certain points about the periphery of the tumor, two points being treated daily. Best results are obtained when the treatments are spread over a period of three to four weeks, with a total dose of 5,000 to 8,000 gamma r, 80 per cent delivered from the side and 20 per cent from the skin surface.

In case of bone involvement radical surgery, with removal of bone, is necessary. Metastatic spread to submaxillary, submental, and cervical lymph nodes is a late development and is best treated with telerradium or block resection.

Fifty-one cases were treated, of which 50 were squamous-cell carcinoma and 1 a mixed-cell salivary gland tumor. For 20 favorable cases, the recovery rate (three years) was 80 per cent, and for 31 unfavorable cases only 9 per cent. The five-year cure rate for the entire series was 35.7 per cent.

Three tables.

E. KRAFT, M.D.  
Newington, Conn.

**Herpes Zoster—Treatment with X-Radiation.** Theodore West, Mary Man, and Catherine Dalton. *Rev. mex. de radiol.* 7: 322-329, July-August-September 1953. (In English)

Primary or idiopathic herpes zoster is a localized unilateral acute infectious disease with segmental distribution, caused by a neurotrophic virus similar to varicella. Secondary herpes zoster occurs in association with systemic disorders, as a complication of leukemia, Hodgkin's disease, metastatic carcinoma, syphilis, and osteoarthritis. Among precipitating agents are systemic medications such as arsenic, bismuth, gold, mercury, iodides, and even large doses of thiamine chloride.

For roentgen therapy the authors use a h.v.l. of 1.1 mm. Cu, with a small daily dosage of 25 to 100 r for at least the first three days, thereafter continuing therapy daily or on alternate days as the progress of the case indicates. Their maximum dosage was 550 r, in air, given in six days, and the minimum was 50 r given in two days. Treatment was directed to vertebral and paravertebral areas at the level of the affected nerves and to areas above and below the site corresponding to the nerve levels.

When cranial nerves are involved, the entire posterior cervical spine is exposed, with the rays directed slightly cephalad. When cranial ganglia are affected, additional exposure is advisable over the ganglia with 50 to 75 r daily for at least three days. For palliation, unfiltered radiation of 100 r is used over the affected skin whenever practical.

The vesicles begin to dry up during the first three days and complete drying is usually accomplished within ten days to two weeks.

The authors have treated 86 cases. A comparison of the results with those in 35 cases treated by other means leads to the conclusion that irradiation hastens

healing of the cutaneous lesions and probably reduces the frequency of complications and sequelae.

E. KRAFT, M.D.  
Newington, Conn.

**Radiation Therapy in Diseases of the Eye.** Robert S. Sherman, Jr., and Michael J. Hogan. *California Med.* 80: 83-90, February 1954.

In radiotherapy of diseases of the eye, careful selection of the radiation source and the use of special shielding make it possible to confine the radiation to diseased tissues. The globe is most effectively protected by a paraffin-coated lead shield inserted beneath the eyelid. X-rays may be limited to the superficial tissues of the anterior segment of the eye by directing the beam tangentially to the anterior surface of the eye and arranging a special applicator so that the lower half of the beam is cut off sharply at its axis (Walton, R. J.: *Brit. J. Radiol.* 25: 9, 1952). The retina may be adequately irradiated while avoiding the lens by directing the beam toward the retina from the temporal and nasal sides at a 45° angle to the sagittal plane. The authors have found the 50-kv.p. x-ray unit with varying filtration to be most reliable and adaptable for most circumstances.

The skin of the eyelid reacts to irradiation like other skin, but more severely. The conjunctiva is quite sensitive to irradiation. Although the cornea is insensitive to small amounts, doses of 4,000 to 6,000 r cause keratitis. The iris, the uveal tract, and the retina are not greatly affected by the usual therapeutic doses.

With superficial radiation ranging in h.v.l. from 1.04 mm. Al to 3.4 mm. Al, satisfactory results were obtained in cases of corneal ulcer, episcleritis, keratoconjunctivitis, pterygium, corneal vascularization, vascularization in the region of the anterior chamber, uveitis, iritis, iridocyclitis, cavernous hemangioma of the eyelid, hemangioid endothelioma, angiomatosis of the retina, and absolute glaucoma. Results were poor in epithelization in the anterior chamber and retinitis. The details of dosage are reported.

The authors also treated 64 carcinomas of the eyelid, using, most commonly, h.v.l. 2.4 mm. Al to 3.4 mm. Al, 20 to 30 cm. target-skin distance, and a tissue dose of 4,000 to 6,000 r in seven to twenty-one days. The best cosmetic results in carcinoma of the eyelid were obtained when the dose was distributed over eighteen to twenty-two days. Among the 64 cases there were only 5 known recurrences. The methods of therapy used in 3 cases of retinoblastoma are also reported. The lesions were apparently controlled.

Two drawings; 5 tables.

RICHARD F. MCCLURE, M.D.  
Redondo Beach, Calif.

**Treatment of Carcinoma of the Thyroid.** Folke Jacobsson. *Acta radiol.* 41: 169-191, February 1954.

This study comprised a series of 144 cases of carcinoma of the thyroid which were treated between the years 1935 and 1946. In 25 per cent of these cases there was no histologic verification. In 20 per cent the patient was under the age of forty. Of the entire group, only 25 per cent were considered operable.

Operability was determined by the extent of the disease process at the time of treatment. In Stage I, the primary tumor was mobile or only slightly fixed to the adjacent structures and no metastases were present.

*Stage II* was similar to *Stage I* except that mobile lymph node metastases were present on one side of the neck. In *Stage III*, the primary tumor was extensively fixed to adjacent structures and there were bilateral and/or fixed cervical lymph node metastases. In *Stage IV*, distant metastases were present.

Operable cases (*Stages I and II*) were treated surgically, with telerradium postoperatively. The five-year survival in these cases was 95 per cent. The surgery varied from simple extirpation of the tumor to total thyroidectomy (the latter was only rarely indicated).

The inoperable cases were irradiated, usually by telerradium. A tumor dose of more than 6,000 r in three or four weeks was obtained in advanced widespread tumors. Telerradium is preferred over ordinary roentgen therapy because larger skin doses are tolerated, with less tracheal and esophageal reaction and less cartilage necrosis. A five-year survival of 35 per cent in *Stage III* was obtained. Three of 24 patients with *Stage IV* lesions survived more than five years.

An important prophylactic measure is the removal of all nodular goiters. In this series of 144 cases, 60 per cent of the patients had noticed a goiter for more than one year prior to the diagnosis of cancer.

One diagram; 4 tables.

RICHARD E. OTTOMAN, M.D.  
University of California, L. A.

**Malignant Teratoma in the Thyroid Gland of an Adult.** Joseph A. Buckwalter and Jack M. Layton. *Ann. Surg.* 139: 218-223, February 1954.

The authors report a case of malignant teratoma which apparently arose in the thyroid gland of a 23-year-old female. A hard tender mass was present in the area of the thyroid gland on the right side of the neck. The basal metabolic rate was -3 per cent; protein-bound iodine 7.4 micrograms per cent. Radioactive iodine studies revealed uptakes of 29 per cent in four hours and 48 per cent in twenty-four hours in the region of the thyroid gland. The area of the tumor took up relatively less of the iodine.

At operation the right lobe of the thyroid was found to be replaced by tumor, which had encircled the trachea. A total thyroidectomy and a right radical neck dissection were performed. Partial obstruction of the right internal jugular vein had occurred. The tumor was composed of anaplastic and truly embryonic tissues corresponding closely to different stages of embryonic development, the bulk of the mass showing varied forms of immature neural tissue. Postoperatively a radioactive iodine survey indicated no residual functioning thyroid tissue.

Four months after operation there were several masses in the right side of the neck and an upper mediastinal mass. External irradiation for a calculated tumor dose of 3,670 r to the right side of the neck and 1,960 r to the upper mediastinum, over a three-week period, resulted in definite regression of the masses.

Six months following surgery there was further enlargement of the neck masses, some new ones had appeared, and there was suggestive metastatic infiltration in the right lung base. A calculated tumor dose of 3,000 r was delivered to the right supraclavicular area, and 4,000 r to the left side of the neck, in a two-week period.

Eight months following the operation the patient's general condition had deteriorated and the entire right side of the neck was occupied by a stony hard sheath

with extension to the left. One hundred fifty milligrams of radioactive colloidal gold were placed in the right pleural cavity following thoracentesis for hydrothorax. A submental node was treated by external irradiation, 1,800 r calculated tumor dose. Death occurred suddenly, approximately fifteen months after the patient had first noticed the neck mass and nine months after operation.

External irradiation in this case offered temporarily effective palliation in the presence of a highly malignant teratoma. The beneficial effects were probably related to the degree of inactivity of the embryonic-like teratomatous tissues.

Two roentgenograms; 1 photomicrograph.

BENJAMIN KAUFMAN, M.D.  
Cleveland City Hospital

**Surgical Technique in the Treatment of Duodenal Ulcer by Antroduodenectomy and X-Ray Irradiation.** Grayton Brown. *Brit. J. Surg.* 41: 359-365, January 1954.

Morbidity following subtotal gastrectomy for duodenal ulcer is too high in the opinion of the author to be regarded as satisfactory. In his series of 94 cases thus treated, 6 suffered from moderate to severe postgastrectomy symptoms, while others complained of minor grades of weakness and failure to regain normal weight. To reduce the incidence of postoperative morbidity the aim of the surgeon should be to remove the duodenal ulcer, to maintain the normal food channel by gastroduodenostomy, and to remove a minimal amount of stomach while avoiding the risk of recurrent ulceration. To accomplish these objectives, the procedure of antroduodenectomy followed by x-ray irradiation of the stomach to reduce the gastric secretion is advocated.

The operation consists of a limited resection including the gastric antrum and first part of the duodenum containing the ulcer. This is followed by gastroduodenostomy. It is considered highly desirable, and usually possible, for duodenal ulcers which are severe enough to require surgery to be excised altogether with the surrounding area of fibrosis. A further mobilization of the duodenum enables a gastroduodenostomy to be performed with more safety than closure of the duodenum as a blind stump.

The author has treated 31 patients by this method. He presents a representative case in which 2,000 r was delivered to the stomach over a three week period, beginning eight weeks after operation. None of the patients became sick following irradiation; serial test meals showed considerable reduction in the secretion of acid, and gastric biopsies revealed moderate atrophy of the acid- and pepsin-secreting cells, together with some inflammatory reaction.

Of the 31 patients treated, 29 had satisfactory postoperative results. Many years must elapse, however, before final assessment of this method is possible.

Two roentgenograms; 1 photograph; 9 drawings.  
WYNTON H. CARROLL, M.D.  
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**Primary Cancer of the Vagina.** James P. Palmer and Sheldon M. Biback. *Am. J. Obst. & Gynec.* 67: 377-397, February 1954.

The authors present a review of 112 cases of

primary cancer of the vagina seen at the Roswell Park Memorial Institute (Buffalo, N. Y.) over a period of thirty-three years. The average age was 57.5 years for the entire group and the incidence was found to be 13 per cent of all gynecological cancer. The disease is uncommonly associated with pregnancy, and pregnancy is not believed to be a primary etiologic factor or to alter the prognosis seriously.

Bleeding was the commonest symptom, occurring in 75 per cent of the patients, followed by pain in 37.5 per cent. Vaginal discharge was noted in 17 per cent and urinary disturbances in 10 per cent. The average duration of symptoms was 7.3 months.

The tumor was on the posterior wall of the vagina in 45.7 per cent of the series and on the anterior wall in 22.4 per cent. Three basic types were represented: papillary, infiltrating, and ulcerative. Ninety-seven per cent of the tumors were squamous-cell carcinoma; 1.8 per cent leiomyosarcoma; 0.9 per cent fibrosarcoma. No relation was found between pathological grades and survival rate.

Treatment of vaginal cancer must be individualized. For flat superficial lesions a surface application of either a single 50-mg. radium source in a Duralumin applicator 1.0 cm. thick or two such applicators in parallel are used; 7,500 gamma r are delivered to the surface of the lesion, or 3,800 gamma r at 2.0 cm. from the surface.

For thicker tumors interstitial radium needles are used, 1.0- to 2.0-mg. radium needles of 1.0 cm. length being placed 1.0 cm. apart in the midplane of the tumor. Approximately 5,000 gamma r at 0.5 cm. beyond the edge of the lesion is considered adequate.

If the lesion is more extensive, radium therapy may be supplemented by external roentgen irradiation. In general, a 400-kv. machine is used. Through multiple pelvic ports converging on the vagina and broad ligaments, 5,000 to 6,000 r are delivered to the tumor in five or six weeks.

Most patients who received adequate radiation experienced some immediate reaction in the bladder and rectum. Fistulas occurred in 4.4 per cent of the patients. A 32 per cent five-year absolute survival rate without symptoms for 75 patients treated up to 1947 is shown, which is an improvement over most previously reported series of cancer of the vagina.

Sixteen tables. THEODORE E. KEATS, M.D.  
University of California, S. F.

**The Epilation Dose.** V. Knoll. *Strahlentherapie* 93: 299-306, 1954. (In German)

The epilation dose is of practical importance for the roentgen therapy of tinea capitis. In the more recent German literature it is quoted as 400 r at 1.25 mm. Al h.v.l. In America a dose of 300 r (measured in air) has

been considered sufficient for epilation. In a series of 30,000 epilations over a period of three years, the author found 300 r to be the correct figure. The first 10,000 cases were treated with five overlapping fields, with the central beam perpendicular to the plane of each field. Unhappily, permanent alopecia was frequently observed in the overlapping areas, especially in the region of the parietal bosses and elsewhere when the head was small.

There are four possible methods of reducing the overlapping of fields:

(1) Small focus-skin distance. This will cause difficulties in positioning. For accurate positioning the author prefers a distance of 25 cm.

(2) Fractionating the treatment or giving a series of small doses instead of the customary large single dose. This is not practical, especially when patients have to travel long distances.

(3) Using a four-field method instead of the customary five fields. This is feasible only when the head is small, as in young children.

(4) Changing the angle of the incident central ray.

The author modified the classical five-field method by angulating the roentgen beam as follows:

For the *frontal field* the tube was tilted 15 to 20 degrees so that the central beam was directed upward toward the sagittal suture area. A distance of 15 cm., however, must be maintained between the incident central beams of the frontal and the parietal field. In children, therefore, the central beam will have to be directed toward the hairline of the forehead.

The parietal field was treated as before.

For the *occipital field* only a slight change was necessary. The tube was tilted 15 to 20 degrees so that the central beam was directed toward the neck. Here again a distance of 15 cm. must be maintained between the incident central beams of the occipital and parietal fields, so that in small children the beam has to be directed toward the hairline of the neck.

The *temporal fields* were subjected to the most drastic modification for minimizing the dangerous overlapping of fields at the parietal bosses. Here the angle between the temporal plane and the central beam must be 120 to 130 degrees in the axial as well as the sagittal direction.

With the classical method, with 300 r, the overlapping dose was as high as 540 r, which meant permanent alopecia. With the modified or angulation method, as used in the last 20,000 cases, the overlapping dose was reduced to 450 r, which was easily tolerated and caused no permanent alopecia.

Six photographs; 3 drawings.

E. KRAFT, M.D.  
Newington, Conn.

## RADIOISOTOPES

**Diagnostic Use of Radioisotopes in a General Hospital.** R. W. Emerick, L. E. Holly, A. H. Joistad, Jr., and K. E. Corrigan. *J.A.M.A.* 154: 493-495, Feb. 6, 1954.

The authors believe that the establishment of a radioactive isotope department in a small general hospital is a feasible and practical procedure. They describe their experience in the Hackley Hospital, Muskegon, Mich. Because of the demands of a high-level radiation laboratory in regard to space, expense, and

equipment, dilute isotope solutions are obtained from a larger hospital and are handled in a low-level radiation laboratory, where adequate protection is attained in minimal space and with little special equipment. A good Geiger-Müller counter and a radiation survey meter are essentials.

Experience has been almost exclusively with  $I^{131}$ . Patients for diagnostic studies are hospitalized for forty-eight hours and receive tracer doses of 50 microcuries. Multiple survey counts are made over two days and all

urine is assayed. The results of 412 tracer studies are summarized.

One photograph. RICHARD E. BUENGER, M.D.  
Chicago, Ill.

**The Radioisotope Program in the General Hospital.** Edith H. Quimby. *J.A.M.A.* 154: 499-501, Feb. 6, 1954.

The author believes that a radioisotope program will soon be a part of most general hospitals. It will almost certainly include thyroid function studies, blood volume determinations,  $P^{32}$  therapy of leukemia and polycythemia,  $Au^{198}$  therapy for ascites, and  $I^{131}$  therapy for exophthalmic goiter, and may, in addition, provide for localization of brain tumors and liver metastases, determination of extracellular fluid volume, isotope clearance measurements for various tissues, and studies of peripheral vascular disease.

The Atomic Energy Commission rules are briefly reviewed and methods for meeting the requirements are discussed.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

**Therapeutic Value of Radioisotopes in a General Hospital.** Carleton B. Peirce. *J.A.M.A.* 154: 495-499, Feb. 6, 1954.

The author emphasizes the grave responsibilities associated with the therapeutic use of radioactive isotopes and points out that in but few instances do they afford control of disease more easily or less expensively than the older methods of chemotherapy and roentgen and radium therapy.

The properties of the isotopes in general are discussed, with special reference to specific problems of external irradiation, intracavitary irradiation, interstitial irradiation, and parenteral administration. The final conclusion is as follows:

In general the entire study of radioactive isotopes as therapeutic agents is still in the realm of research and should be so considered. No general hospital (a) that discovers and treats fewer than 500 new cases of malignant disease or 100 of thyroid disease per year, (b) whose staff is not fully diversified and especially skilled in clinical physiology and radiation therapy, with an experienced radiation physicist or biophysicist, (c) whose staff will not subrogate all personal interest to close teamwork in such an investigative program, and (d) whose administration is unwilling or unable to afford the physical facilities required should consider therapeutic application of the radioactive isotopes at this time.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

**Radioactive Phosphorus as a Diagnostic Aid in Ophthalmology.** J. W. Bettman and Victor Fellows. *Arch. Ophth.* 51: 171-179, February 1954.

Counts of radioactivity after the injection of radioactive phosphorus are subject to many variables. Some of these, such as the dose of the isotope and the length of time after injection, are common to all organs. A special factor operative in ophthalmology is the fact that the eyeball acts as a hollow sphere so far as radioactivity is concerned; only the vascular tissues produce any great radioactive response. Because of this fact, the count is normally obtained from a very thin layer of tissue—the vascular uveal tract. Should the Geiger-Müller tube be held over a rectus muscle, the

greater thickness of the underlying vascular tissue will lead to an increased count. Again, if the counting tube is pointed backward toward the macula, the tube receives impulses from a much greater length of uveal and extraocular tissues, thus increasing the count.

The "hollow-sphere effect" accounts for an increase in counting rate as the tube is moved away from the eyeball before the count begins to fall off. With a thicker radioactive tissue below the tube, such as a tumor, there is no preliminary increase in the count, but only a continuous falling off. Variations due to vascularity are also encountered if a tumor is present. This is true not only of different tumors but of different areas within the same tumor, the more vascular areas producing much faster counts than the less vascular areas. A slower rate may be obtained over avascular tumors, such as retinoblastoma, than over the normal eye.

An inflammation which increases the blood supply to the eye results in much greater radioactivity and could give the same response as a tumor, or even a greater one. If the counts are performed a number of days after the injection of the isotope, it is theoretically probable that a more accurate differentiation between an actively growing tumor and other tissue simply with more blood flowing through it could be made.

The authors conclude that the use of  $P^{32}$  in the diagnosis of ocular tumors suffers from a number of physiological, anatomical and physical difficulties which have to be overcome. A particularly difficult problem is posed by tumors near the posterior pole of the eye. The isotope might, however, be an extremely valuable diagnostic tool (1) if a counter were designed that could be applied directly over a tumor located near the posterior pole, (2) if the variables mentioned were carefully controlled, and (3) if, perhaps, the counts were made at much longer intervals after injection.

Six figures; 6 tables.

**Proaccelerin Deficiency Following Irradiation with Therapeutic Doses of Radiophosphorus.** Herbert Vetter and Helmut Vinazzer. *Blood* 9: 163-172, February 1954.

This study presents the results of a detailed analysis of blood coagulation defects observed in a group of 7 patients following their exposure to a therapeutic dose of radiophosphorus for polycythemia. In all but one patient, the doses used were between 7 and 11 mc. A significant decrease in the proaccelerin content of the plasma was observed on the second day after treatment, lasting from three to sixteen days. Coagulation was severely impaired in only one patient, who received a total of 18 mc. in two months. No effect was found in one patient after a dose of only 5 mc.

The occurrence of a similar blood coagulation defect in many patients with liver cell damage, its regular occurrence following the use of radiophosphorus, and the fact that this isotope contributes a considerable dose to the liver, make it conceivable that the effect is due to a transient impairment of liver function.

Three graphs; 1 table. E. E. TENNANT, M.D.  
Denver, Colo.

**Iron Metabolism in Steatorrhea. The Use of Radioactive Iron in Studies of Absorption and Utilization.** J. Badenoch and Sheila T. Callender. *Blood* 9: 123-133, February 1954.

It is known that iron absorption is impaired in



steatorrhea. This explains the poor response of patients to iron administration for an associated iron-deficiency anemia. However, the results of this study with radioiron given to 16 patients with steatorrhea, 12 patients with hypochromic anemia without steatorrhea, and 3 subjects without anemia, suggest that poor absorption in patients with steatorrhea may not be the sole factor involved.

In 2 patients, the amount of iron absorbed daily should have been enough to have maintained a normal iron balance. Both had recurrent anemia without any evidence of blood loss. Excess iron loss, probably through increased excretion (impossible to evaluate with labeled iron), must be considered as a possible answer.

Further evidence along this line was found in 3 patients with idiopathic steatorrhea who did not manifest iron deficiency. Neither utilized more than 2 per cent of oral dosage of iron. It seems possible that in some cases anemia is not manifested until an excessive excretion cannot be compensated for, due to impairment of absorption by the steatorrhea.

Six graphs; 1 table.

E. E. TENNANT, M.D.  
Denver, Colo.

**Uptake of Radioiron in Tissue Storage Compounds in Normal and Hemosiderotic Mice and Its Utilization for Erythropoiesis.** John K. Hampton, Jr. *Am. J. Physiol.* 176: 20-24, January 1954.

The uptake of radioiron in tissue storage compounds and its utilization for erythropoiesis was studied in normal and hemosiderotic mice.

In normal mice, the amount of intravenously injected radioiron which appeared in the ferritin fraction of the liver seemed to be determined by the initial size of that fraction. The relationship was a direct one.

In mice made hemosiderotic by intravenously injected saccharated iron oxide, the hemosiderin fraction accumulated the same amount of the injected radioiron as control animals. However, in these animals the ferritin fraction contained more of the radioiron than in controls.

The specific activity of the blood of hemosiderotic mice was only half that of the controls, suggesting either a depression of erythropoiesis, mixing of the radioiron with the enlarged non-radioactive stores, or a time lag during which a large amount of non-radioactive bone marrow iron already at the site of utilization was being used. Mixing of radioactive and non-radioactive storage iron, if it occurred, was not complete.

Hemorrhage caused a marked reduction of the radioiron in both the hemosiderin and ferritin fractions of livers. This reduction in radioiron was much greater than the fall in total chemical iron. This supports the findings of others that mixing of iron recently received with stores already present is poor and that the last iron received will be the first used for erythropoiesis.

Additional evidence is provided that iron from both hemosiderin and ferritin is readily available for erythropoiesis.

Two illustrations.

**Radiation Sterilization. VI. Relative Merits of Cathode Rays and Gamma Radiations.** Samuel A. Goldblith and Bernard E. Proctor. *Nucleonics* 12: 32-35, February 1954.

This article compares the use of gamma rays from

cobalt 60 and 3-mev electrons for purposes of food sterilization. The distribution of dose produced in water by electrons of 1-mev, 2-mev, and 3-mev energies are shown in a figure. The 3-mev electrons have a maximum range of about 1.4 cm. and are thus appropriate for irradiation of only relatively thin objects. The highly penetrating gamma rays from cobalt 60 are capable of dissipating energy throughout large objects. The uniformity of the dose is greatly improved by the use of multiple sources surrounding the irradiated object.

A series of separate experiments in which cultures of *E. coli* were irradiated with 3-mev electrons and with cobalt 60 gamma rays were performed under circumstances which resulted in both uniform and non-uniform dose distributions. For the same average dose, the non-uniform distribution was less effective in sterilization, emphasizing the greater efficiency of uniform distributions.

Comparison of the bactericidal effectiveness of 3-mev electrons and cobalt 60 gamma rays under similar dose conditions indicated a relative effectiveness ratio of unity.

Five figures; 2 tables.

JOHN S. LAUGHLIN, Ph.D.  
Memorial Center, New York

**Control of Trichinosis by Gamma Irradiation of Pork.** Sylvester E. Gould, Henry J. Gomborg, and Frank H. Bethell. *J.A.M.A.* 154: 653-658, Feb. 20, 1954.

Commercial irradiation of raw pork may prove to be a practical means of controlling trichinosis. A dose which will produce sterility of the adult *Trichinae* or one sufficient to prevent maturation of the larvae to adult forms will break the *Trichina* cycle and thus prevent the development of the muscular phase of trichinosis in the potential host.

Earlier experiments (*Am. J. Path.* 29: 323, 1953. *Abst. in Radiology* 62: 162, 1954) with x-rays had shown that, while a relatively large dose (750,000 r) is required to kill *Trichina* larvae *in vitro*, as little as 3,500 to 5,000 r is effective in preventing reproduction of the parasites. Exposure of trichinous meat in thickness of less than 1.5 cm. to a dose of 15,000 r rendered the larvae in the meat non-infective to experimental rats. Similar results were obtained with cobalt 60 (*Science* 118: 75, 1953). A dose of 15,000 r produced sexual sterilization of the larvae, and 18,000 r prevented 99 per cent from maturing to adult forms.

The experiments described are a continuation of those with cobalt 60, designed to determine the effect of gamma radiation from this source on trichinous pork. Doses of 9,500 to 10,350 r to infested meat produced sexual sterility in 74 to 98 per cent of gravid female *Trichinae* recovered from the intestines of rats after six days. A dose of 11,830 r produced sterility in 100 per cent. In irradiating meat, account must be taken of the loss in radiation dose as the distance from the source is increased. Practically, the authors suggest a dose of 30,000 r for prevention of maturation of the larvae to adult forms.

It is believed that waste fission products of atomic radiation might produce a similar effect at lower cost.

Four illustrations; 2 tables.

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Coos Bay, Ore.

## RADIATION EFFECTS

**Mycosis Fungoides. Report of a Case Terminating in Myelogenous Leukemia.** John E. LeDonne. New England J. Med. 250:240-242, Feb. 11, 1954.

A forty-six-year-old male was seen in the Skin Clinic of the Massachusetts General Hospital in January 1947, with a generalized and pruritic eruption of twenty years duration. Scattered over the entire cutaneous surface of the body, excluding the face, were scaly, infiltrated, erythematous patches. A few shotty inguinal and axillary lymph nodes were present. Blood counts and urinalysis were normal. A skin biopsy revealed the typical changes of mycosis fungoides.

At this time low-voltage x-ray therapy was begun, being administered as a "spray" at weekly intervals to different body sections in a dose of 30 r, unfiltered, to each section (100 kv., 10 ma., target-skin distance 61 cm.). This treatment was continued for five months, resulting in complete relief of pruritus and almost complete clearing of the widespread dermatosis. Six weeks later the lesions recurred and urethane therapy was initiated, without any appreciable improvement. The skin lesions even progressed. The hemocytologic picture remained normal throughout this period.

In October 1948, the patient was again examined. Blood counts, urinalysis, blood chemical determinations, and chest films were within the limits of normal. The skin biopsy again showed mycosis fungoides. A series of nitrogen mustard injections, (6.3 mg. each day for six days) produced progressive and marked improvement clinically and healing of all the ulcers. Many of the skin lesions disappeared. In February 1949, there was again a recurrence of skin lesions and another course of nitrogen mustard was given. From March 1949 through November 1950, the patient was given weekly or biweekly "spray" irradiation to different body sections of 30 to 180 r each. Throughout this time the white blood count remained consistently above 6,000. Courses of ACTH in November 1950 and January 1951 relieved the pruritus but had no apparent effect on the skin lesions. Skin biopsy at this time again showed mycosis fungoides and in addition there were noted radiation changes in the corium. From March to December 1951, weekly or biweekly x-ray treatments were again given, in doses ranging from 45 r to 300 r, unfiltered. During the latter half of this period a progressive anemia and leukocytosis developed, and in January 1952 the patient was admitted to the hospital for the fifth and last time for further study and treatment. It was calculated that over the preceding five-year period he had received, in fractional doses, 24,630 r (unfiltered) of superficial, low-voltage radiation to the entire skin surface.

Examination of the blood showed a hemoglobin of 9.5 gm. The white cell count was 15,800, with 26 per cent neutrophils, 32 per cent lymphocytes, 2 per cent monocytes, 26 per cent eosinophils, 4 per cent basophils, 6 per cent myelocytes, and 4 per cent myeloblasts. Platelets were abundant. There was no enlargement of the liver or spleen. The heart, lungs, and mediastinum were within the limits of normal. Bone-marrow preparation revealed a marked shift to the left in the myeloid series. Megakaryocytes were numerous. Blast and early forms were also noted in the peripheral blood smear, and these changes were regarded as consistent with early myelogenous leukemia. The patient died in coma on the eightieth day of hospitalization.

The final blood count showed 8 per cent myeloblasts, 60 per cent promyelocytes, 8 per cent myelocytes, 10 per cent metamyelocytes, 10 per cent neutrophils, 2 per cent eosinophils and 2 per cent lymphocytes. Platelets were absent from the smear.

It is suggestive that the leukemia developed as a sequel to the large amounts of superficial, generalized x-ray therapy administered in this case.

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**Herpes Zoster after Roentgen Treatment.** H. G. Schmitt and F. Thierfelder. Strahlentherapie 93: 417-425, 1954. (In German)

The authors observed 9 cases in which herpes zoster developed after roentgen irradiation of various body parts, in 6 cases for carcinoma and in 3 for benign conditions. It appeared mainly in the irradiated segment, though neighboring areas were also affected. An etiologic relationship is held to be probable.

One photograph. LEWIS L. HAAS, M.D.  
University of Illinois

**Nine Cases of Radiation Damage of the Osteocartilaginous Chest Wall with One Fatality.** Rudolf Birkner and Johannes Schaaf. Strahlentherapie 93: 454-465, 1954. (In German)

In 9 cases cartilage and bone damage was found in the anterior chest wall six months to ten years after irradiation, performed in 6 cases for breast cancer, in 2 cases for bronchogenic carcinoma, and in 1 case for sarcoma of the clavicle. The damage occurred in the ribs and in the clavicle, consisting of atrophy, necrosis, or spontaneous fracture of the affected bones. In the fatal case a retrosternal abscess developed, with pericarditis. Treatment was given at 60 to 180 kv., and the estimated tissue doses to the affected bones were between 4,000 and 10,500 r. The authors also calculated the effective dose in the bones in rep, multiplying the tissue dose with a factor representing the increased absorption in the involved bones. They found that the grade of the damage does not depend upon the effective bone dose alone, but that other unknown biological factors play a part. Individual variations in radiosensitivity are probable.

Six roentgenograms; 8 photographs.

LEWIS L. HAAS, M.D.  
University of Illinois

**The Problems and Therapy of the Radiation Syndrome.** K. Fochem. Strahlentherapie 93: 307-316, 1954. (In German)

In a series of 270 cases, the radiation syndrome was found mostly in the fifth decade of life, less frequently in patients above fifty and below forty. Dark-haired patients were less affected than those with red or blond hair. Working people were less frequently involved than non-workers. The author found the following symptoms, in order of frequency: fatigue (in earlier life), lack of appetite, nausea, headache, and intestinal disturbances (in later life).

The radiation syndrome is caused by the products of cell disintegration, with resultant protein intoxication and associated changes, throwing an excessive burden of detoxication on the liver. Factors which combine to

contribute to the occurrence of the reaction are: (1) poor general condition, (2) poor state of nutrition, (3) age, (4) complexion (predominantly blond and red), (5) psychic factors, (6) extent of underlying disease.

As to therapy, Nautisan, vitamin B<sub>1</sub> and B complex are mentioned. Vitamin C is helpful but may stimulate tumor growth. In the present series levulose (Laevosan) was administered intravenously. In animal experiments it was found superior to dextrose as far as liver protection is concerned. The injection is relatively easy, as the viscosity is low, and clogging of veins does not occur as with dextrose solutions. Marked improvement was noted in regard to weight loss, anorexia, leukopenia, nausea, and intestinal disturbances.

Eight tables, 1 chart.

E. KRAFT, M.D.  
Newington, Conn.

**Effect of Levulose on Radiation Sickness.** K. Fochem. *Strahlentherapie* 93: 466-472, 1954. (In German)

In a second paper (see preceding abstract), the author considers the effect of levulose in controlling the unfavorable reaction to irradiation. Radiation sickness is due to protein intoxication as a result of cell disintegration. Examinations with the bromsulphophthalen test have shown that damage to the liver parenchyma is produced in this way. Levulose is capable of detoxicating the liver and diminishing the untoward symptoms. The more commonly administered drugs, Nautisan, etc., result only in symptomatic relief and have no etiologic influence on the radiation sickness.

A number of cases are cited in support of the author's conclusions.

Two illustrations.

LEWIS L. HAAS, M.D.  
University of Illinois

**Polonium in Urine of Miners Exposed to Radon.** Mary Sultzer and John B. Hursh. *Arch. Ind. Hyg. & Occup. Med.* 9: 89-100, February 1954.

Concentrations of the radon decay product, Po<sup>210</sup>, varying from about 2 to 38  $\mu\text{c}$  per liter were found in the urine of miners working in the uranium mines of the Colorado Plateau. In unexposed laboratory personnel no urinary polonium could be detected.

The polonium in the miners' urine is believed to come from Pb<sup>210</sup> stored in the bone which, in turn, is derived about equally from radon daughter products deposited in the lung and radon accumulations in the body fat (10 kg. of fat). Ingested radium as a source of the urinary polonium is excluded, since it is shown that, even though body burdens of radium equal to the maximal permissible level were accumulated by the miners (which is unlikely), this amount of radium would contribute a negligible amount of polonium in the urine.

The experimental results reported here were found to be in agreement with calculations made on the basis of probable values for the fate in the body of the chemical elements in the radon decay scheme.

The possibility of inferring the accumulated radiation dose to the lung from the measurement of urinary polonium and the specification of a urinary polonium level prognostic of probable lung injury await further study.

## EXPERIMENTAL STUDIES; RADIOBIOLOGY; RADIOPHYSICS

**Brain and Liver Phosphorus Metabolism in the Acute Irradiation Syndrome.** Warner H. Florsheim and M. E. Morton. *Am. J. Physiol.* 176: 15-19, January 1954.

The investigation described here was undertaken in the hope that alterations in the "blood-brain barrier" might be reflected in the extent to which peripherally administered radiophosphate would penetrate to the brain tissues. Since *in vitro* work did not show any impairment of the phosphorus metabolism of irradiated brain tissue, the incorporation of the tracer should furnish a valid measure of the phosphorus supply to the brain from the blood in the intact animal.

Male albino mice ranging from four to thirteen weeks in age were irradiated with the filtered output of a 250 kv., 15 ma., G.E. x-ray machine. Filtration consisted of 1 mm. Al and 0.5 mm. Cu. The dosage ranged up to 20,000 r (in air). Irradiated animals and controls of the same age and sex were injected intramuscularly with 10 to 22 c.c. of P<sup>32</sup>O<sub>4</sub> within an hour after irradiation. The animals were killed by decapitation after twenty-one or twenty-four hours, the brains were ashed, and the material was assayed for P<sup>32</sup> activity. As a means of comparison with a non-neural tissue, the uptake of P<sup>32</sup> by the livers of irradiated and control mice was similarly determined.

It was found that the incorporation of peripherally administered tracer phosphate into the brain tissue was not changed by irradiation with 20,000 r of "hard" x-rays. This would indicate that any possible alteration in capillary permeability or vascular supply produced by irradiation does not affect the brain's supply of phosphate nor its ability to incorporate this into organic compounds. In addition, the phosphorus me-

tabolism of liver after irradiation was not demonstrably altered from the control. The phosphorylative efficiency of liver slices irradiated *in vitro* likewise remained unchanged. Clinical and histological effects of irradiation could not be attributed to changes in the levels of either blood glucose or brain cholinesterase.

Two photomicrographs; 5 tables.

**Pathological Changes in Neurons, Neuroglia, and Blood-Brain Barrier Induced by X-Irradiation of Heads of Monkeys.** C. D. Clemente and E. A. Holst. *Arch. Neurol. & Psychiat.* 71: 66-79, January 1954.

Contrary to published statements that there is a relative radioresistance of the adult nervous system, reports from both clinical and experimental sources reveal that irradiation can produce extensive neuronal pathology and neurologic disorders. Primary impairment of neurons, of neuroglia, and of the vascular system has each been cited as the principal cause of the observed neurological abnormalities.

In the normal animal there is a selective barrier between the blood and the brain, as has been demonstrated by the intravenous or intraperitoneal injection of vitally staining acid aniline dyes, such as trypan blue, where the material so injected stains the tissues of all other organs of the body except the central nervous system proper. In the work here reported the authors utilized permeability to trypan blue as a measure of impairment of the blood-brain barrier resulting from exposure of the head of *Macaca mulatta* monkeys to ionizing radiation and correlated this impairment with the pathology of the neuroglial and neuronal elements.

Single x-ray doses ranging from 1,500 to 6,000 r were

administered to the heads of 37 monkeys while the remainder of the body was shielded. Two unirradiated animals were used as controls. A G.E. Maximar 250 kv.p. unit was the source; the dosage rate was 118 r per minute at a focal mid-cranial distance of 35 cm. as measured in a Masonite phantom; the animal was rotated at a rate of 1 rpm. Trypan blue was injected intraperitoneally at intervals before and after irradiation. Sections of the brains were prepared by several staining methods.

Blood-brain barrier changes, astrocytic degeneration, and neuronal damage were most intense in those monkeys receiving 4,500 and 6,000 r, as measured. There were, however, permeability abnormalities and tissue destruction in lower-dose groups. The most frequent sites of trypan blue penetration following irradiation were the hypothalamus and medulla. Astrocytic degeneration was confined to areas stained by the dye. Neuronal injury, although more severe in these areas, was generally less localized.

The trypan blue method is probably not a sensitive enough means of assessing permeability changes to the extent that it would allow estimation of the relative importance of direct and indirect neuronal effects of irradiation. The authors feel, however, that this work definitely establishes the impairment of the blood-brain barrier as a most important factor in brain damage from irradiation. The greater radiosensitivity of the hypothalamus and medulla, both vital centers, is the point of particular interest.

Ten photomicrographs; 1 photograph; 8 drawings; 1 table.  
JOHN F. RIESSER, M.D.  
Springfield, Ohio

**Neurological and Electroencephalographic Effects of X-Irradiation of the Head in Monkeys.** J. A. T. Ross, S. R. Leavitt, E. A. Holst, and C. D. Clemente. *Arch. Neurol. & Psychiat.* 71: 238-249, February 1954.

The heads of 37 monkeys were subjected to single exposures of x-irradiation in doses of 1,500 to 6,000 r. Electroencephalograms and neurologic examinations were made over periods as long as eight months after irradiation, and the pathological changes were studied terminally.

Radiation sickness as manifested by the usual gastrointestinal and hematological signs was not encountered. The animals demonstrated a general depression of activity, blindness, opisthotonic and grand mal tonic and clonic seizures, ataxia, tremors, paraplegia, and partial facial paralysis.

Early electroencephalographic abnormalities consisted of a slowing of activity, with an increase in amplitude; spiking and grand mal seizure patterns occurred. In later months survivors (1,500 r) showed focal abnormalities.

The changes in the brain during the acute period consisted of injury to neuronal and neuroglial elements, and of alterations in capillary permeability. The hypothalamus, optic chiasm, and dorsal part of the medulla oblongata were most affected. The brains of the animals receiving 1,500 to 3,000 r (subacute), examined at two to three weeks, also showed neuronal damage but little or no edema, inflammation, or neuroglial injury. In later months only widespread pinpoint foci of glial scarring were found.

In the acute stage the abnormalities were probably the result of increased intracranial pressure with edema and inflammation. In the subacute stage the signs

were probably the result of widespread neuronal degeneration. In later months the seizures were presumably related to the presence of widespread miliary scarring of the brain.

The threshold for the appearance of signs of injury to the nervous system of the monkey seems to be about 1,500 r, given as a single exposure.

Two photographs; 5 electroencephalographic tracings; 1 table.  
THEODORE E. KRATS, M.D.  
University of California, S. F.

**Histochemical Changes in Irradiated Ovaries. II. Carbohydrate and Lipid Localization.** Alvan G. Foraker, Sam Wesley Denham, and M. Harlan Johnston. *Arch. Path.* 57: 30-35, January 1954.

In a former report (*Arch. Path.* 55: 147, 1953. *Abst. in Radiology* 61: 987, 1953), the authors described the histochemical changes in irradiated ovaries, with particular reference to sites of dehydrogenase activity. They now record the changes induced in the ovary by irradiation as reflected by periodic acid and Sudan black B staining.

Twelve virgin female rabbits ranging from six to eight weeks in age and from 1,180 to 3,140 gm. in weight were each given 400 r in air in a single dose to a 6.0-cm. external port over the left ovary. The factors of irradiation were: constant potential 200 kv., 18 ma., half-value layer 1.2 mm. Cu. Distance was 50 cm., and the dosage rate 50 r per minute. With these factors, at a depth of 2.0 cm., the tissue dose to the ovary is approximately the same as the air dose. Four weeks after irradiation 6 of the rabbits were given intravenous injections of urine from pregnant women (Friedman test) and 6 were injected with urine from non-pregnant women. Tissues from all ovaries were stained with the periodic acid stain to demonstrate glycogen and other periodic acid-positive substances and with Sudan black B to demonstrate lipid. The results showed (1) little evidence of irradiation damage of the stromal cells either in pattern or in lipid content; (2) obliteration of many of the ova in irradiated ovaries, those remaining being largely atretic with no stainable lipid and with a considerable deposition of a periodic acid-positive substance, not glycogen; (3) little evidence of ability of the irradiated ovaries to respond to the hormonal stimulation of the Friedman test.

Eight photomicrographs.

**Blood Histamine Levels in Swine Following Total Body X-Radiation and a Flash Burn.** Hamilton Baxter, John A. Drummond, Bram Rose, L. G. Stephens-Newsham, and Robert G. Randall. *Ann. Surg.* 139: 179-185, February 1954.

An experimental study of the blood level of histamine in swine following total-body irradiation, as well as after total-body x-radiation plus a thermal burn, is presented on the assumption that abnormal production of histamine or "H" substance may be responsible for acute radiation sickness.

Twenty young swine were divided into two groups of 10 each. All were exposed to 400 r total-body irradiation and one of the groups received in addition a thermal burn of 10-15 per cent body surface shortly following irradiation. The physical factors used were 220 kv.p., h.v.l. 1.1 mm. Cu, dosage rate 10 r per minute measured in air at a target-skin distance of 80 cm. Blood levels of histamine were determined in terms of micrograms per cubic centimeter of whole blood prior



to irradiation and periodically after irradiation and thermal trauma for thirty days. A complete autopsy was done on all animals which succumbed.

The results obtained from this experimental study can be summarized as follows:

(1) Mortality in the group of 10 swine exposed to roentgen radiation alone was 20 per cent, whereas that of the group subjected to irradiation and thermal trauma was 90 per cent.

(2) Autopsies in the two groups showed similar findings pertaining to the acute radiation syndrome.

(3) In the group receiving x-radiation alone there was a fall of blood histamine after the second day from an average of 1 microgram per cubic centimeter of whole blood to 0.3 to 0.2 micrograms about the tenth to the fifteenth day. Subsequently, there was a gradual rise among 8 surviving animals, although the histamine level never reached the pre-irradiation level. In the group of animals subjected to both x-irradiation and thermal injury, there was a rise of histamine from a pre-irradiation level of 1.1 micrograms to 1.5 on the second post-irradiation day, with a subsequent rapid fall to 0.1 on the thirteenth post-irradiation day. The only animal which survived out of the 10 animals in this group showed a gradual rise of blood histamine to the pre-irradiation level.

A review of the literature in regard to the relation of histamine to acute radiation sickness is presented. The authors conclude that in the present study there appeared to be a definite parallelism between the fall of blood histamine level and increasing severity of symptoms of acute radiation sickness, although the physiological-pathological responses to radiation injury are multiple.

Two graphs.

THOMAS HWANG, M.D.  
Cleveland City Hospital

**The Effect of Surgery on Dogs Following Whole-Body X-Irradiation.** Gordon E. Gustafson and Frank A. Cebul. *Surg., Gynec. & Obst.* 98: 49-54, January 1954.

To test the effect of surgery following whole-body irradiation the authors selected 18 pairs of mongrel dogs and irradiated all of them. Ten pairs received 200 r and 8 pairs 300 r delivered at 220 kv., h.v.l. 1.35 mm. Cu. One dog of each pair was subjected to a resection of 15 cm. of ileum and side-to-side anastomosis about twenty hours after irradiation.

Seven of the control dogs and 8 of the operated dogs died. Thus surgery was without significant effect on mortality. The most common autopsy finding was a profound bacterial pneumonitis. In the operated group, the white blood count on the first postoperative day was elevated 41 per cent above the mean pre-irradiation level; in the control dogs the count at the same time was decreased 37 per cent.

The authors suggest that the results would not be nearly so favorable for surgery if a major procedure were delayed until an animal was already sick from irradiation.

Seven tables.

GEORGE R. KRAUSE, M.D.  
Mt. Sinai Hospital of Cleveland

**Effect of Total Body Irradiation on Wound Closure.** Michael Radakovich, Arthur M. Dutton, and John A. Schilling. *Ann. Surg.* 139: 186-194, February 1954.

Experimental work was carried out in an attempt to ascertain the effect of irradiation incident to atomic

warfare on wounds thus precipitated. Surgically excised wounds of comparable length were inflicted on the backs of rats, and the animals were subjected to varying amounts (150 r, 450 r, and 650 r) of total body irradiation at different intervals, some before and some after injury. A photographic record of wound healing was kept for tabulation. Comparative groups were housed in similar environments.

The study encompassed two aspects affecting wound closure: the local effect of ionizing irradiation on the wound and the role of systemic effects in relation to wound closure. Previous studies indicated retardation of healing when a dose of approximately 1,000 r (air), or up to 1,000 mg. hours of radium, was applied locally to a linear wound. This effect was not noted in the present experiments, in which lower dosages were used. With 650 r, a slight increase in the rate of healing was observed in the surviving animals.

In view of the proneness of irradiated animals to develop serious infection, the failure of the systemic effects to influence wound closure is significant. Previous studies had shown a high incidence of septicemia in irradiated animals if gut trauma occurred. This factor was not evident here. Nor did the marked weight loss in the irradiated animals, due to low food intake, have any significant effect on wound closure.

Four illustrations; 4 tables.

G. R. HANSON, M.D.  
Cleveland City Hospital

**Immediate Effect of X-Radiation on the Isolated Striated Frog Muscle.** Herbert B. Gerstner, Charles P. Powell, and Everett O. Richey. *Am. J. Physiol.* 176: 9-14, January 1954.

The authors describe an investigation of the effect of irradiation on striated muscle. Experiments were performed with 120 male leopard frogs (*Rana pipiens*) of approximately equal weight. Preparation, irradiation, and testing of the isolated gastrocnemii were carried out at 20° C. Pairwise simultaneous testing of non-irradiated and irradiated muscle of the same animal was conducted under equal conditions. Radiation factors were 260 kv.; 18 ma.; inherent filtration, 0.25 mm. copper; additional filtration, bottom of Pyrex glass beaker; target-muscle distance 8 cm. At this distance the dose rate was approximately 6,000 r/min. (in air).

According to the effect upon the isolated muscle, three dose ranges of irradiation were distinguished: (1) a low dose range (0 to 30 kr) in which no significant immediate alteration from normal was found; (2) a medium dose range (30-150 kr) in which muscle function was immediately compromised and gross morphological changes in coloration, translucency, and length occurred; (3) a high dose range (above 150 kr) in which an immediate, complete abolishment of muscle function was evidenced, associated with morphological changes similar to, but more pronounced than, those in the medium dose range. The results of the experiment may be briefly summarized as follows: in the isolated striated muscle of the frog, medium doses of x-rays produce radiation contracture; high doses cause radiation rigor.

Three illustrations; 2 tables.

**Adenosine Triphosphatase and 5-Nucleotidase Activity of Hematopoietic Tissues of Irradiated Animals.** Kenneth P. Dubois and Donald F. Petersen. *Am. J. Physiol.* 176: 282-286, February 1954.

The authors report the results of detailed studies on

the influence of whole-body irradiation on the adenosine triphosphatase and 5-nucleotidase activity of the spleens and thymus glands of rats and mice (radiation factors: 250 kv.p., 15 ma., 0.25 mm. of copper and 1 mm. of aluminum added filtration, target distance 75 cm., and dose rate 30 to 35 r per minute). With sublethal doses of irradiation these tissues were found to exhibit an increased ability to hydrolyze adenosine triphosphate and 5-adenylic acid, an effect which became evident as early as three hours after irradiation, reaching a maximum within seventy-two hours. The alteration in enzyme activity by irradiation was reversible, the rate of reversal depending upon the dose of x-rays.

Within the range of 25 to 400 r, the increase in the adenosine triphosphatase activity of the spleens and thymus glands of rats was directly related to the dose of radiation administered. Doses in excess of 400 r did not evoke additional increases. A similar relationship between x-ray dosage and nucleotidase activity was observed in the spleens and thymus glands of rats when doses between 100 and 400 r were administered.

Lethal x-ray doses caused an irreversible increase in the adenosine triphosphatase and 5-nucleotidase activity of the spleens and thymus glands of rats and mice. Six graphs.

**Humoral Factor in Irradiation Protection: Modification of Lethal Irradiation Injury in Mice by Injection of Rat Bone Marrow.** Charles C. Congdon and Egon Lorenz. *Am. J. Physiol.* 176: 297-300, February 1954.

The failure to obtain reproducible results in the protection of irradiated mice with guinea-pig bone marrow (*Radiology* 58: 863, 1952) left unsettled the question whether or not a humoral factor can operate across species barriers in protection against total-body irradiation. Evidence now presented demonstrates that bone marrow from the rat will prevent the death of irradiated mice.

The irradiated mice were from the genetically homogeneous hybrid LAF<sub>1</sub> and Strain A. Both male and female animals were used at about three months of age. The 30-day LD 50 for LAF<sub>1</sub> mice is approximately 650 r, and for Strain A mice approximately 560 r. The mice received a tissue dose of 800 r or 900 r, either of which is a 21-day LD 100 for either type of mouse. Radiation factors were 186 kv.p., 20 ma., filtration 0.25 mm. Cu plus 1.06 mm. Al. Two tubes opposite each other were used to obtain a uniform tissue dose; their foci were 54 cm. from the center of the mice. Dosage rate was 100 r  $\pm$  5 per cent/min.

Bone marrow from Osborne-Mendel rats given intravenously to irradiated LAF<sub>1</sub> mice reduced the mortality at twenty-one days to 0-30 per cent. In irradiated Strain A mice, bone marrow from Osborne-Mendel rats brought about a reduction in mortality to 45 per cent at twenty-one days. Bone marrow from Sprague-Dawley rats administered intravenously to irradiated LAF<sub>1</sub> mice gave less protection—30-80 per cent mortality at twenty-one days. With intraperitoneal administration, mortality was 100 per cent. In irradiated Strain A mice receiving Sprague-Dawley rat bone marrow intravenously the mortality at twenty-one days was 85 per cent. Bone marrow from Fischer rats, when given intravenously, did not alter the 100 per cent mortality of irradiated Strain A mice. The same type of bone marrow given intraperitoneally to

irradiated LAF<sub>1</sub> mice produced a reduction to 86 per cent.

The variation in the protective effect of bone marrow from the different strains of rats requires further study. One graph; 1 table.

**The Biological Effectiveness of Thermal Neutrons on Mice. I and II.** James T. Brennan, Payne S. Harris, Robert Emerson Carter, and Wright H. Langham. *Nucleonics* 12: 48-56, February; 31-35, April 1954.

This article (in two parts) describes a series of experiments designed to determine the relative biological effectiveness of thermal neutrons compared with 250-kv. x-rays for lethality in mice. Part I is devoted to physical measurements and dosimetry considerations, while the second part is primarily concerned with the biological results.

A thermal column of the Los Alamos homogeneous reactor was employed as the source of thermal neutrons. The column was constructed to provide a maximum ratio of neutron to gamma-ray exposure. Considerable effort was devoted to the problem of determining accurately the thermal neutron flux and the amount of inherent gamma-ray contamination. Other corrections due to the presence of the experimental animals were also determined. The absorption measurements necessary to determine the neutron flux and the relative amount and energy of the gamma rays are described in detail. Lithium was used as an absorber in these measurements because of its high cross section for neutron capture and relatively unimportant gamma-ray production.

Sixteen hundred Swiss mice between eight and eleven weeks of age were used in the experiment. The comparison of the resulting LD 50 doses for thirty-day lethality indicated that  $1.3 \times 10^{10}$  neutrons/cm.<sup>2</sup> gave an effect equivalent to 1 roentgen of 250 kv.p. x-rays.

Twenty-four illustrations; 2 tables.

JOHN S. LAUGHLIN, Ph.D.  
Memorial Center, New York

**An X-Ray Dose-Action Curve for Eye-Color Mutations in *Mormoniella*.** David T. Ray and P. W. Whiting. *Biol. Bull.* 106: 100-106, February 1954.

Visible mutations have been induced in widely diverse species of organisms by x-rays and other ionizing radiations. Dose-action curves for these visible mutations have been shown in several organisms to be similar to those for lethals. These curves are of the straight-line type of direct proportionality, i.e., for a given increment of dose at any interval within the range, a similar proportion of mutations is added. The authors obtained a dose-action curve for eye-color mutations in *Mormoniella*, the chalcidoid wasp, and found this also to be of the straight-line type, indicating that single hits produce the mutations. However, an insignificant dip, occurring at the mid-point, 2,680 r, suggested the possibility of a second factor.

One graph; 3 tables.

**Effect of Conventional and High-Energy Radiations on Tumors.** Gunther Barth and Felix Wachsmann. *Strahlentherapie* 93: 395-399, 1954. (In German)

The specific ionization of different energies is different. Therefore, different "equivalent" doses are required to produce the same radiation effect. However, the quantitative difference is not uniform. For

different tissues and different reactions the quantitative ratio of the equivalent doses of various energies also differs. The authors assume that the differing ratio may cause qualitative, elective differences in the biological effect.

Hoffmann and Wachsmann found, in comparative irradiation of Walker carcinoma of the tails of rats, that with the 5-mev electron beam the carcinoma disappeared without reaction in the surrounding healthy tissues, while with 200-kv. x-rays this was accompanied by a serious reaction in the adjacent tail portions. Barth, Katrakis and Wachsmann, in work as yet unpublished, expected to increase the elective effect by fractionated dosage, but their experiments on the skin of rabbits showed rather a decreased difference in the biological effects of the two radiations. But the authors believe, on a theoretical basis, that a great divergence in electivity may occur in certain conditions, to such degree that, for example, conventional x-ray irradiation will damage the tumor in 85 per cent and the normal tissues simultaneously in 60 per cent, while the high-energy radiation will damage the tumor electively in 85 per cent and the healthy tissue in only 30 per cent.

Two illustrations.

LEWIS L. HAAS, M.D.  
University of Illinois

**Introductory Remarks on the Dosimetry of Ionizing Radiations.** U. Fano. *Radiation Res.* 1: 3-9, February 1954. **X-Ray Dosimetry: General Principles and Experimental Factors.** Leonidas D. Marinelli. *Ibid.* pp. 23-33. **Measurement of Slow Neutrons and Coexisting Radiations.** P. S. Harris. *Ibid.* pp. 34-42.

These three papers are part of a symposium on Physical Measurement in Radiobiology presented at the 1953 meeting of the Radiation Research Society.

Fano seeks to show how the conditions of exposure may favor or hinder the accuracy of dosimetry and its subsequent interpretation. It is important to bear clearly in mind in the early planning of an experiment what level of accuracy is desired in regard to the dose delivered to particular portions of the treated material and in regard to the linear energy transfer. To achieve good accuracy, one must analyze and evaluate the effects which result from the chain-wise generation of secondary radiations and which involve a complex flux of radiation at any point and frequently rapid variations of this flux from point to point. These effects may be minimized by careful design which strives to reduce the inhomogeneity of the radiation flux and its variation from point to point within the treated material.

Ionization in gases has proved to be the most expedient method of measuring x-radiation doses for radiological purposes. Marinelli reviews briefly the basis of this method and describes the use of the open air-ionization chamber and the thimble air-ionization chamber. He then discusses some of the factors that a radiobiologist with access to a typical x-ray machine, and in possession of a typical commercial dosimeter, would have to consider in order to measure the dose correctly. The principle of photon-electron equilibrium is explained. Marinelli recommends that, when there are no facilities to measure the radiation correctly, radiobiologists should follow closely the procedures recommended to radiologists for the specification of their treatments, taking care in particular to ensure photon-electron equilibrium.

The accurate measurement of slow neutrons for biological studies is a difficult and important problem. Measurement is complicated because of the nature of the methods required for the production of an adequate neutron flux for biological investigations. It is further complicated because there is no method at present for the direct determination of tissue dose. Harris discusses the use of indirect methods which have been developed that enable the radiobiologist to measure thermal neutrons in terms of relative biological effect (RBE) with reasonable accuracy. He states that the determination of a correct value for the RBE of slow neutrons will depend on the particular biological system used and on the development of an absolute physical measure of rep or total energy deposited in that system.

The symposium also includes a paper by Moyer entitled "Neutron Physics of Concern to the Biologist."

**Secondary Roentgen Radiation from Wax, Aluminum, Iron, and Lead at Tube Voltages Between 40 and 170 kv.** Lars Lorentzon. *Acta radiol.* 41: 201-208, February 1954.

Several graphs for use in radiation protection evaluation have been established by the author. These are concerned with the secondary radiations from wax, lead, aluminum, and iron. The highest value was obtained for wax, and presumably similar values would obtain for the secondary radiation from other light substances such as tissue, water, and wood. Absorption curves for the secondary radiation from wax, lead, aluminum, and iron are available in four separate figures for various tube voltages up to 170 kv.

One figure; 6 graphs.

RICHARD E. OTTOMAN, M.D.  
University of California, L. A.

**Density Effect in  $\gamma$ -Ray Measurements.** G. N. Whyte. *Nucleonics* 12: 18-21, February 1954.

This article is concerned with the effect of the polarization density phenomenon on ionization measurements. In the development of the Bragg-Gray relation it was assumed that the energy lost by an ionizing particle traversing a definite quantity of a given medium was independent of the density of that medium. However, theory indicates that the greater the density of the medium, the less energy (per unit mass) it will extract from the passing ionizing particle. This phenomenon is a consequence of the shielding effect of molecules along the path of the particle, which reduces the probability of distant collisions. The effect is more pronounced with increasing electron energy.

The author considers the application of the correction for this effect to previously reported measurements (8.41 r/mg./hr. at 1 cm.) of the ionization produced in air enclosed in solid-wall chambers by radium gamma rays. Application of the calculated correction reduced the above value to 8.2 r/mg./hr. at 1 cm., which is in agreement with other experimental data taken with a free-air chamber.

The calculations in this article and their comparison with experiment tend to confirm the existence of the polarization density effect and to explain the discrepancy between measurements of ionization produced by radium gamma rays.

Three graphs; 2 tables.

JOHN S. LAUGHLIN, Ph.D.  
Memorial Center, New York

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